Case Studies for Vulnerability Assessment Techniques (VAT) I, II, and III Workshops

NOAA Coastal Services Center

How to View the Case Studies

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The case studies are organized by workshop.

VAT I Workshop Case Studies

Title: **The Vulnerability of the Energy Sector in Costa Rica**

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Hazards examined: Earthquakes, floods, volcanic eruptions (emissions, earthquakes), drought and landslides

Study emphasis: Mitigation and disaster response.

Summary: Offers an estimation of the cost of repair to damaged and/or destroyed structures, the costs for the provision of replacement energy, the costs of lost production (hours of labor lost) and exports.

Vulnerability Indicators: Impact (major or minor) by hazard type (earthquake, flood, volcanic eruption (emissions, quake) drought, landslides) to energy sector infrastructure with estimated direct and secondary losses by energy type.

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: Investment in vulnerability reduction, planning event impact response.

Data Requirements: Inventory of all energy sector infrastructure components and associated roads segments and seaports; hazard zonation maps, damage assessments from previous events, current sector infrastructure and operations costs.

Output:
1. Cost of repair of damaged/destroyed infrastructure
2. Cost for the provision of replacement energy
3. Cost of lost production
4. Cost of lost exports
5. Hours of labor (work) lost

Results of Application at Case Study Site: At the time (immediately prior to the May 1991 earthquake) senior sector management (national and international) showed no interest in vulnerability reduction. Subsequent to the earthquake, at their own initiative, technical personnel formulated and received support in (a) purchasing and pre-positioning replacement equipment for essential vulnerable infrastructure, (b) preparing and implementing a disaster preparedness plan for the metropolitan area of San Jose, (c) introducing the issue of redundancy in electrical grid development plans.

Lessons Learned:

1. As a last resort, governments and senior sector officials will focus on vulnerability issues following a disaster.
2. Capable, enthusiastic technical personnel when properly prepared can force initiatives at opportune moments and gain support.
3. Financial and economic benefits may occur, even in the short to medium term by investing in vulnerability reduction.

Case study title: **A Probable Maximum Loss Study of Critical Infrastructure in Three Caribbean States—Dominica, St. Lucia and St. Kitts and Nevis.**

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Case study emphasis: Hurricanes, tropical storms

Summary: This study offers a methodology for estimating structural damage and monetary losses from hurricanes. The information developed in this study is useful to participating governmental organizations and financial institutions, in that it provides a basis for review of issues relating to insurance coverage for critical infrastructure that is at risk to damage from hurricanes.

Date that model application was completed: 1999

Case study geographical location: Caribbean: Dominca, St. Lucia, St. Kitts and Nevis

Vulnerability assessment indicators: Estimates of losses ($$)

Methodology data requirements: Detailed information on infrastructure characteristics (age, design, quality of construction, replacement costs), damage functions for building types represented, impacts from maximum credible events.

Direct participants in the application of the model of the vulnerability assessment:

Multinational, National, and State/Provincial Governments
Multilateral Development Agency
Multilateral Finance Agency
Bilateral Development Agency

Economic and social sector participants directly involved: airports, electricity generation plants, waste management system, health service facilities, road networks, utility poles, seaports, wharves, schools, public buildings

Methodology objective: To develop quantified estimates of losses for critical facilities and infrastructure due to hurricane effects.

Methodology output: Cost estimates for damages and losses from credible natural hazard events. In this study, the only hazard considered was tropical storms. In addition to the final cost estimates, the infrastructure information that was collected locally for this study is useful for local management of the countries' public infrastructure.

Results of methodology application at case study site: The aim of this case study was to produce a reasonable estimate of potential financial losses from a hurricane event, for use by participating governments and regional financial institutions to review issues of insurance coverage for critical infrastructure that is at risk to damages from hazard events.

Lessons learned: When undertaking multi-jurisdictional studies such as this one, it is important to ensure that the local data collection and cost estimation procedures are consistent across jurisdictions. In this study, loss estimates for the individual countries cannot be compared directly, due to some difference in the local data collection procedures.

Title:	**Comparative Vulnerability to Natural Disasters in the Caribbean**	
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Hazards examined:	Multi-Peril	
Study emphasis:	Economic development through a comprehensive examination of economic variables, agricultural output and numbers of persons affected by hazards/disasters.	
Summary:	Offers a measure of comparative vulnerability to natural hazards/disasters, based upon the number of people affected and the number of deaths associated with historical episodes.	

Vulnerability Indicators: Economic variables, agricultural output, people affected

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: Economic Development

Data Requirements: Economic variables; persons affected: 1970-1999

Output: Alternative measures of comparative vulnerability of economies of the Commonwealth Caribbean to natural disasters.

Results of Application at Case Study Site: The study utilizes secondary macroeconomic data, or data on number of persons affected, for the countries of the Commonwealth Caribbean. Problems are highlighted with each of the measures of comparative vulnerability considered. Different rankings of comparative vulnerability for Caribbean countries emerge from the use of different measures of vulnerability. However, a pattern emerges as to the most vulnerable and least vulnerable countries, that conforms largely to expectations. A compromise measure of comparative vulnerability to natural disasters is generated, based on the number of people affected and the number deaths associated with historical episodes.

Lessons Learned: Historical data alone is insufficient to assess vulnerability to possible future disasters. Expert assessment of future episodes is required, based on aspects such as historical incidence and impact, mitigation measures in place, concentration of development, economic structure, and climatic and geophysical variables.

Title:	**Community Vulnerability Assessment Methodology – New Hanover County, NC**	
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Hazards examined:	Multi Peril	
Study emphasis:	Economic development, disaster preparedness, disaster response and reconstruction/recovery issues.	
Summary:	Offers a GIS-based product useful for making vulnerability-related decision and analyses. Primary goal(s) of product is/are assisting community leaders with decisions relating to, hazard mitigation planning recommendations, disaster preparedness, response and recovery activities and land use and development planning.	

Vulnerability Indicators: Critical Facilities, Social, Economic, Environmental

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: All of the above

Data Requirements: Numerous GIS-based data layers and historical hazards data

Output:

1) New methodology developed and described on CD-ROM using case study example.
2) GIS project developed for use in case study area for vulnerability related decision-making and analysis.
3) Initial results and recommendations based on application of vulnerability assessment methodology.

Results of Application at Case Study Site: This application was used to assist the community leaders in making hazard mitigation planning recommendations. The results of each analysis are also being used to support various disaster preparedness activities, as well as in designating special consideration areas for disaster response and possible reconstruction efforts. The application was also designed to support land use and development planning decisions.

Lessons Learned: Limitations of spatial data for use in consistent vulnerability analysis are significant.

1) Availability of spatial data to support multi-disciplinary analysis is limited.
2) The necessity for continuous local input requires time-consuming commitment to local planning processes.
3) There is a lack of consistent and accurate probability and risk data to support local decision-making. In addition, it is extremely difficult to get the scientific community to reach consensus or acknowledge the fact that local decisions will be made in the absence of any data.
4) Multi-hazard analysis can be made too complex for acceptance and use in local decision-making.

Title: **Sustainable Development Planning for Eight Puerto Rico Municipalities**

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Hazards Examined: Multi-Hazard

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary:

This study involved the development of an integrated hazard assessment methodology that used a GIS-driven constraint analysis to evaluate multiple hazards. It employs a "vulnerability index" that relates the intensity of past damages to the reoccurrence interval for each hazard, then compares different hazards to create a composite hazard map. The integrated hazard assessment was then tied to a more traditional land suitability analysis to identify future growth areas, sensitive development areas where Best Management Practices (BMPs) should be implemented, and high hazard areas where intense development should be discouraged.

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

Title:	**Dominica National School Vulnerability Reduction Plan**
Contact(s):	Name: Stephen Bender Agency: OAS 1889 F Street Washington, D.C. 20006 Phone: (202) 458-3005 Fax: (202) 458-3560 E-mail: sbender@oas.org
Hazards examined:	Hurricanes, volcanic eruptions, floods, landslides, droughts, earthquakes and fires.
Study emphasis:	Economic development, risk management and reduction strategies as well as disaster preparedness and mitigation tactics.
Summary:	Offers a specific plan for reducing structural vulnerability of schools to the effects of destructive natural phenomena. For each structure, the plan addresses issues such as location, technical characteristics and condition, damage history as well as planning process guidance for designing, building and maintaining less vulnerable schools, profiles on specific projects for vulnerability reduction and recommendations for the development of improved disaster preparedness and response strategies.

Vulnerability Indicators: Expected damage by type of structure and natural hazard flood, hurricane, landslide, earthquake, volcanic eruption

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: Formulation of projects for vulnerability reduction, data for further development of school maintenance program, data for emergency preparedness school shelter program, draft material for policy changes covering school infrastructure development.

Data Requirements: School inventory with map location and structural characteristics, natural hazard zonation maps, school repair and maintenance data.

Output: National School Vulnerability Reduction Plan covering (1) school inventory with location, technical characteristics and condition (2) natural disaster damage history of school stock (3) policy recommendations for vulnerability reduction (4) school planning process guidance for designing, building and maintaining less vulnerable schools (5) profiles on specific projects for vulnerability reduction of building stock and better maintenance (6) recommendations for improved disaster preparedness and response.

Result of Application at Case Study Site:

The project had three main components:

I. Survey of Schools/Shelters – creation of vulnerability profiles

It was asked to select up to 20 public shelters that needed to be retrofitted. A survey form was developed and applied by local engineers under the guidance of an OAS consultant. The survey of properties helped prepare a profile of the condition of shelters, all 20 properties selected were school buildings. In addition, a vulnerability inventory of all public schools for future retrofitting work was completed.

II. Development of National Plan to Reduce the Vulnerability of School Buildings to natural disasters

A series of workshops was held focused on the formulation of national plan to reduce the vulnerability of school buildings to natural disasters. During Workshop I, the concept and contents of a school vulnerability reduction program were introduced, an outline for a national plan to reduce vulnerability was agreed upon, and working groups were established. After Workshop I concluded, the groups continued to gather information and formulate the draft national plan.

The first draft of the national plan was presented at Workshop II. This workshop gave work group members an opportunity to discover strengths and weakness and critique the overall plan. The resulting document was be presented to the cabinet of ministries on July 1998 for review and adoption.

III. Maintenance of School Buildings

To prolong the life of a structure, it must be properly maintained. Unfortunately, school buildings are often poorly maintained and little money, if any, is typically set aside in recurring budgets for school building maintenance. This contributes to the building's vulnerability to natural disasters. A school building maintenance manual was developed for non-technical staff (school principals, head masters, and teachers). The manual contains a series of checklists and hints on how to prolong the life of school buildings.

Lessons Learned: The Caribbean is no stranger to disasters. Mother nature has shown her dominance and strength repeatedly in the form of hurricanes, volcanic eruptions, floods, landslides, droughts, earthquakes, and fires. This project has successfully united individuals from a variety of sectors, disciplines, and responsibilities to create a National School Vulnerability Reduction Plan and guide the implementation of the CDB Shelter/Schools Retrofit loan program. These individuals would not normally share information or work together on school design and construction issues. A forum for dialogue and collaboration was created by taking something useful to the community at large, a school building, and trying to come up with a strategy and plan to make it safer. It was perceived as a project that everyone would benefit from and was destined for success.

The groundwork has been laid for a regional school vulnerability reduction campaign. It is our belief that awareness has been raised about the importance of safe schools and shelters. For this reason, the players involved in this project will continue to work together to implement the National Plan to Reduce the Vulnerability of School Buildings to Natural Disasters. The project has also raised the issue of design criteria for schools under construction with international and bilateral support. This issue is now being discussed with donor organizations.

The project has definitely raised the problem of seismic resistant design in professional circles. This issue had previously been shunned by local professionals not familiar with engineering design criteria, reinforced by a long period of time since the last major earthquake in the region.

Support from regional and international lending institutions is forthcoming. The 20 properties evaluated during the course of this project will be retrofitted to an acceptable standard using criteria developed through this project and loan commitments with the CDB. This pilot effort serves as an excellent example of how vulnerability reduction programs can be implemented throughout the region.

Title:	**Vulnerability Assessment Study of the Ecuadorian Agricultural Sector**
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Hazards examined:	Multi-peril
Study emphasis:	Economic development and potential loss estimations, particularly in the agricultural sector.
Summary:	Offers a worst-case scenario approach to estimating potential crop losses resulting from disaster(s). Expected changes in investment, loans at risk, number of jobs involved and lost income and export earnings are used as barometers to estimate extent of effect on the local economy.

Vulnerability Indicators: Impact on investment, income, debt, employment and export earnings for selected crops due to the impact of natural hazards.

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: Site selection for the introduction of new crops, and their development and management; ag sector financial and economic analysis for public policy on price supports and technical assistance; potential loss estimations

Data Requirements: Agricultural production map for selected crops together with economic data, natural hazard zonification maps; support infrastructure maps.

Output: For a worst case scenario of maximum crop value loss (in the field or on the way to market) resulting in the expected changes in investment, loans at risk, number of jobs involved, lost income and export earnings.

Results of Application at Case Study Site: The study influenced a parallel study in the sector on site selection of new cacao growing areas. The public administration changed shortly after the completion of the study and the new administration showed little interest in the study's findings, but within two years was forced to deal with the impact of the 1992-1993 El Niño episode. No known follow-up on the study, but input data was used to prepare subsequent sector development programs.

Lessons Learned: Even with the presence of a post-disaster situation, public sector interest in using, updating and developing more disaster resistant policies, programs and projects may not be present. The results will be waning interest in technical development by responsible technical staff in incorporating vulnerability reduction into sector development plans.

Title:	**Natural Hazards Exposure Mapping in the United States**

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Hazards examined: Earthquakes (eventually to be extended to flooding and wind events).

Study emphasis: Economic development, risk management and reduction as well as disaster preparedness, response and recovery strategies.

Summary: Offers a standardized earthquake loss estimation methodology (HAZUS) which is intended to provide local, state and regional emergency management officials with the necessary tools to plan and stimulate efforts to reduce risk from earthquakes as well as prepare for emergency response and recovery efforts following an event. A national exposure index is developed which is intended to provide a relative assessment of exposure from combined hazards and demonstrate the geographic distribution of hazard exposure for regional planning efforts.

Natural Hazards Exposure Mapping in the United States

Stuart Nishenko, Mitigation Directorate, Federal Emergency Management Agency

In the past, much of the research on natural disasters was based on developing an understanding of the *hazard* – the location, size, and frequency of earthquakes, floods, hurricanes, tornadoes, etc. - instead of the *risk*, which is a product of the hazard, the population and building exposure, and the vulnerability. Policy, land use, and development decisions at the Federal, state, and local level are risk-based and need appropriate inputs. Areas at high risk may not always be coincident with areas of high hazard.

Detailed information about natural hazards is available for different regions of the United States through the efforts of various Federal agencies such as the Departments of Agriculture, Commerce, and Interior including the US Geological Survey, the National Weather Service, the Army Corps of Engineers, the National Flood Insurance Program, the National Science Foundation, and professional organizations such as the American Society of Civil Engineers. There are few corresponding risk maps or standardized methodologies, however, that could be used for risk-based planning and mitigation. Most of the general understanding about risk is restricted to property damage, insured portfolio losses, and casualties related to specific scenario events or regional probabilistic loss studies (NRC, 1989; NIBS, 1994). Without such standardized technologies, it is infeasible to compare levels of damage or losses between regions of the country or between hazards.

In support of the National Mitigation Strategy, the Federal Emergency Management Agency (FEMA) has developed a standardized earthquake loss estimation methodology, HAZUS (Hazards US) that uses a nationally consistent hazard, vulnerability, and inventory database to estimate earthquake losses throughout the United States. Similar models for flood and wind loss are currently under development. HAZUS is intended to provide local, state, and regional emergency management officials with the tools necessary to plan and stimulate efforts to reduce risk from earthquakes and other natural disasters and to prepare for emergency response and recovery following the events.

The nationally consistent building inventory in HAZUS provides an ideal platform to assess and compare hazards exposure across multiple regions throughout the United States. The analysis summarized in this study consists of overlaying a series of national scale hazards maps (coastal wind, riverine and coastal flooding, and earthquake ground motions) onto the HAZUS inventory of residential and non-residential buildings and population. The economic exposure to each hazard, at some threshold value, is presented in terms of the replacement value for residential and non-residential buildings and a per capita estimate. Both the magnitude of the exposure as well as the location of that exposure are used to develop a national exposure index. This index is intended to provide a relative assessment of exposure from these combined hazards and demonstrate the geographic distribution of hazard exposure for regional planning efforts.

In this analysis, the exposure to the 100 year or 1% annual chance flood, coastal wind (>120 mph) or earthquake (>20% g) event represents approximately $3 trillion or 25% of the total replacement value for the national building stock and is comparable for each event type (i.e. exposure to wind, earthquake and flooding are each approximately $1 trillion). Geographically, however, these exposures are quite different. Hurricane wind exposure is spread along the Atlantic and Gulf coasts, flood exposure is ‘uniformly’ distributed across the nation, and earthquake exposure is primarily concentrated in the state of California. Exposure to the 500 year or 0.2% annual chance flood, wind, and earthquake events represents approximately $6.6 trillion or 50% of the building inventory replacement value and is dominated by hurricane wind events.

Title:	**A GIS-Based Hazards Assessment for Georgetown County, SC**	
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Hazards examined:	Hurricanes, tornadoes, hail/severe storms/wind events, earthquake, wildfire, drought and toxic chemical releases (roadway, railway and fixed facilities.	
Study emphasis:	Mitigation planning, damage assessments and post-disaster response.	
Summary:	Offers a summary of social and biophysical vulnerability of study area. The hazards assessment involved four primary elements including hazards identification and occurrence, identification of vulnerable populations, the integration of these two elements in a geographical or spatial context and the identification of the social and infrastructure context. The goal of the assessment is the identification of those areas most physically and socially vulnerable to hazards. Social vulnerability involved the incorporation of eight separate indicators including total population, number of housing units, female, nonwhite, people over 65 years of age and under 18, mean home value and number of mobile homes.	

Vulnerability Indicators: Social and biophysical (detailed below)

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: The assessment, handbook, and baseline information developed in this research are essential for pre-impact mitigation planning, damage assessments, and post-disaster response. A primary goal of this assessment was to create a method of identifying the risk posed by multiple hazards for the purpose of promoting mitigation.

Data Requirements: A key component of any vulnerability assessment is the acquisition of systematic, quality baseline data, particularly at the local level. These data provide inventories of hazard areas and vulnerable populations, as well as the ability to conduct analysis. This approach is data intensive, requiring indicators from a wide-range of sources.

Output: The hazards assessment for Georgetown County, South Carolina followed a methodology utilizing a geographic information system (GIS). The findings of this study are conveyed in the final report, *A GIS-Based Hazards Assessment for Georgetown County, South Carolina*, which summarizes the social and biophysical vulnerability of Georgetown County. The culmination of the research is an assessment of place vulnerability, a merging of the hazard zones and social vulnerability. A handbook, *Handbook for Conducting a GIS-Based Hazards Assessment at the County Level*, details a methodology for conducting a hazards assessment using an all-hazards approach. In addition to these two documents, the final results include a CD-Rom containing all GIS data layers for the county.

Results of Application at Case Study Site: The assessment portion of the project involved four primary elements: hazards identification and occurrence, identification of vulnerable populations, the integration of these two elements in a geographic or spatial context, and the identification of the social and infrastructure context. The primary goal of this assessment was to identify those areas most physically and socially vulnerable to hazards. In terms of the delineation of individual hazard threats, there were generally four main steps. These included hazard identification, data acquisition, the calculation of hazard frequency of occurrence, and delineation of the hazard zone. The hazards incorporated into this study consisted of hurricanes, tornadoes, hail/severe storms/wind events, earthquake, wildfire, drought, and toxic releases (roadway, railway, and fixed facility). These data were all derived from publicly available federal and state sources. At the completion of this portion of the analysis, the composite hazard vulnerability was assessed within the GIS. The social vulnerability portion of the analysis involved incorporating eight indicators: total population, housing units, female, nonwhite, people over 65 years of age and under 18 years of age, mean house value, and mobile homes (primarily from U.S. Census information). A composite social vulnerability based on these factors was computed within the GIS. The culmination of the project involved combining the social and the biophysical vulnerability assessments to arrive at place vulnerability. The final analysis provides the means to examine where vulnerable people are in relation to hazardous areas. For example, one could identify areas that had both high social and high biophysical vulnerability. In addition to the identification of social, biophysical, and place vulnerability, the relationship of these to infrastructure (evacuation routes, structures, utilities, railroads, bridges, dams, airfields, ports, and response facilities) and special needs populations (day care centers, nursing homes, health centers, hospitals, and schools) was also evaluated.

Title:	**Vulnerability Assessment of a Port and Harbor Community to Earthquake-Tsunami Hazards**	
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Hazards Examined:	Seismic, Tsunami	
Study emphasis:	**Please select all that apply:** Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application	
Summary:	This project focuses on building the resiliency of Pacific Northwest port and harbor communities to earthquake and tsunami hazards. To achieve this goal, a community-based planning process is being developed and tested in two communities. The process is designed to integrate local stakeholder values, technical expertise, and GIS-based scenario development.	

Vulnerability Indicators:
Resource vulnerability and community vulnerability, including buildings, infrastructure, populations, response operations, community recovery, local economy, and environmental resources

Data Requirements:
- GIS and other data on seismic and tsunami hazards for potential scenarios
- GIS and other data to facilitate vulnerability assessment, e.g., geology, ground shaking potential, soils, elevation, bathymetry, structural footprint, utilities, roads, demographics, historic landslides
- Information to support two community workshops: one focusing on Vulnerability Assessment and the other on Mitigation Options Development

Output:
- Community partnerships – a partnership network of port and harbor users, agencies, and businesses is created
- GIS-based exposure maps – numerous maps were created that showed which resources were exposed to the various hazards

- Prioritized vulnerability issues – stakeholders prioritize the numerous vulnerability issues, with regards to their impact on the entire port and harbor community

Results of Application at Case Study Site:
Results of the community vulnerability assessments are prioritized at later mitigation workshops. From these discussions, a series of sector-specific mitigation action plans are created. These sectors include a) emergency services, b) lifelines, c) waterfront industries, d) tourism, lodging, retail businesses and residences, and e) community planning and the environment

Lessons Learned:
- Building stakeholder partnerships early in the project is critical for project success
- Inclusion of stakeholder input has allowed assessments to elevate from resource exposure to community vulnerability
- Elevation from resource vulnerability to community vulnerability is an important step for prioritizing community mitigation actions
- Assessments from both geographic and functional (i.e., sector-specific) viewpoints provide more robust representation of community issues

URL(s) or bibliographical references to/for publications about your case study:
http://ports-tsunamis.oregonstate.edu

Case study title:	**Hazard Assessment and Vulnerability Reduction Plan for Jeremie, Haiti**

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Case study emphasis: Economic development, disaster preparation and mitigation opportunities

Summary: The study offers a ranking of the impact of prevalent hazards on the study area, with respect to a variety of hazard impacts on the population, particularly life, livelihood, property and health measures. The study offers a detailed list of interventions that can be undertaken locally in Jeremie to reduce the vulnerability to hazards.

Date that model application was completed: May 1999

Case study geographical location: Jeremie, Haiti

Vulnerability assessment indicators: Life, health, property, livelihood

Methodology data requirements: Hazard maps, population survey (sample) results.

Direct participants in the application of the model of the vulnerability assessment:

Local Government
Multilateral Development Agency
Multilateral Finance Agency
Bilateral Development Agency
Non Governmental Organization

Economic and social sector participants directly involved: The study was carried out with the direct assistance of local volunteers and local agencies, such as the Red Cross.

Methodology objective:
Identify the primary hazards affecting Jeremie and identify the priority hazards, as recognized by the population. Mitigation opportunities to address these hazards and their environmental causes selected.

Methodology output:

1) A ranking of the importance (impact) of the prevalent hazards, as identified through the population survey.
2) A quantification of the impacts of hazards on the population, by life, livelihood, property and health measures.
3) A list of interventions to reduce hazard vulnerability.

Results of methodology application at case study site:
The project identified 50 interventions that can be undertaken locally to reduce vulnerability to hazards, as outlined in the population survey. Some of these interventions are being reviewed by the local disaster committee and others have been selected by other donors for support.

Lessons learned:
Involvement of local participants in carrying out the survey of residents was critical to the success of this project. These participants assisted with focusing the questions on the survey form to the local conditions, delineating appropriate neighborhood boundaries and interpreting survey responses. Most significantly, however, was that through their involvement in this project, the local surveyors gained significant knowledge about community survey techniques and about hazard mitigation interventions.

Title:	**Seismic Vulnerability Assessment of Southwestern Indiana using HAZUS**

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Hazard examined: Earthquakes

Study emphasis: Disaster preparedness and response.

Summary: Offers a HAZUS based loss estimation study of Southwestern Indiana. HAZUS is intended to provide local, state and regional emergency management officials with the necessary tools to plan and stimulate efforts to reduce risk from earthquakes as well as prepare for emergency response and recovery efforts following an event.

Vulnerability Indicators: Loss estimates

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: Disaster preparedness and disaster response

Data Requirements: Building inventory, emergency facilities, Transportation facilities, high potential loss facilities, direct damage data, direct economic and social loss etc.

Output: The HAZUS project is designed to produce loss estimates for use by local authorities in planning for earthquake loss mitigation, emergency preparedness and response and recovery. The methodology deals with nearly all aspects of built environment, and with a wide range of different types of losses. The methodology has been tested against the experience from several past earthquakes and against the judgment of experts. Subject to several limitations, HAZUS has been judged capable of producing results that are credible for the intended purposes. Uncertainties are inherent in any such loss estimation methodology. They arise in part from incomplete scientific knowledge concerning earthquakes and their effect upon buildings and facilities, and in part from the approximations and simplifications necessary for comprehensive analyses. The possible range of uncertainty is best evaluated by conducting multiple analyses, varying certain of the input parameters to which losses are most sensitive.

Results of Application at Case Study Site: HAZUS should be regarded as a work in progress. Initial studies were undertaken based on default data. Results from these studies provided momentum to continue data collection and improve the current data. Additional calibration studies are also continuing, and improvements and additions are underway.

Lessons Learned: Active participation from local government, academia, private industries and pubic agencies is essential for the success.

Title:	**Implementation of the IDNDR-RADIUS Project in Latin America – Antofagasta, Guayaquil, Tijuana**
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Hazard examined:	Earthquakes
Study emphasis:	Economic development, disaster awareness and preparedness, response planning, and recovery efforts and risk management strategies.
Summary:	Offers an evaluation of seismic risk at each location and potential risk management plans to be employed. Additionally, the study provides earthquake scenarios and action plans and promotes and facilitates collaboration among officials from participating cities in order to share experiences, identify common problems and solutions and form international partnerships.

Vulnerability Indicators: Vulnerability functions were developed for structures and infrastructure to estimate damage due to a probable earthquake

Economic Development, Disaster Preparedness, Disaster Response and or Disaster Reconstruction Application: Action plans for seismic disaster preparedness of the cities were prepared including emergency response planning and recovery programs

Data Requirements: Information on city's structures, infrastructure, institutions and administration

Output: Working in close collaboration with local people in three Latin American cities, the project evaluated the seismic risk of those cities, prepared risk management plans based on those evaluations and, most importantly, raised awareness of the community on seismic risk. Significant progress was attained toward the incorporation of the entire community in risk management activities. Members and institutions of the society participated actively throughout the project and committed efforts were made to set up the conditions that will allow the establishment of long-term initiatives to reduce the seismic risk.

Results of Application at Case Study Site: Very significant progress has been attained in increasing awareness among the communities in the three cities and actions are already being taken to implement the plans prepared by the project. Examples of the actions being taken include the following:

- The Municipality of Guayaquil created the Unit for Risk Management of the City which, among other things, will be in charge of implementing the plan prepared by RADIUS.
- The government of Antofagasta has allocated one million dollars to relocate 6 schools that were found to be located in a tsunami affected area.
- The Municipality of Tijuana has allocated US $80,000 for the implementation of microzoning studies for the city. The results will be used in urban planning.
- The Municipality of Guayaquil is preparing a new building code for the city.
- Three small neighbor cities of Antofagasta, Chile have started similar projects; using the RADIUS methodology. The same is happening in Ensenada and Mexicali near Tijuana.
- The industrial sector of Tijuana asked the Municipality for assistance in the estimation of its seismic risk. The industry offered to support seismic safety efforts for the schools in exchange for the Municipality's assistance.
- Tijuana organized and hosted the UN-sponsored RADIUS Symposium in October 1999, in which representatives of more than 50 cities of the world discussed the RADIUS achievements, lessons, and possible implementation in other communities.

Lessons Learned: RADIUS proved to be important and effective for several reasons. It produced tangible results, such as the earthquake scenarios and action plans, that are already being used by the cities; The project also promoted and facilitated the collaborative work of cities worldwide that interacted to share experiences, identify common problems and solutions, and form international partnerships. Most importantly, RADIUS proved to be very effective in incorporating the entire community in the management of the seismic risk.

What worked to make RADIUS a successful project?

The UN's name. It would have been more difficult to implement the project without the name of the UN behind. The UN's name attracted the attention arid participation of the local governments, increased credibility and trust, and facilitated access to information and institutions required for the implementation of the project.

Seed money. The project offered assistance that was attractive but not enough to complete the project. This generated local funding to cover the project's costs and, therefore, created a feeling of ownership in the locals. Since the city was paying for the project, they expected and demanded useful results from the project.

Presence of international advisers. They not only provided guidance and expertise, but also increased the project's credibility, facilitated communication among locals, especially between scientists and local authorities, and eliminated jealousy and distrust among the various institutions participating in the project.

Careful selection of the cities. We made sure that there would be sufficient information to complete the project, good communication between government and scientists, and that collaboration among the various institutions involved was possible.

The most important factor that contributed to the project's success was the feeling of ownership of the project developed by the local people. They felt that it was their project, their work, their ideas, and their contribution to the safety of their city. Key to the RADIUS success were the hard work and commitment of the many people that participated in the implementation of the project in each city, especially the members of the local steering committees whose leadership and enthusiasm made this project possible.

Title: **Rural Roads Vulnerability Reduction Assessment, Mitigation Measures, and Training**

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Hazards Examined: Multi-hazard

Study emphasis: Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: This study involves an assessment, through community involvement, surveys and subsequent reviews of given rural road conditions, and the development of roads ‘worklists’ that are aimed at defining needed improvements and “disaster proofing” roads and roadway systems. Outputs have included identification of specific needed road work with use of the worklist and drawings, and conducting training on basic design, construction, and repair measures applicable to minimizing vulnerability of the roads and reducing environmental damage. (See attached summary writeup)

Vulnerability Indicators:

-Roads located in vulnerable areas (on landslides, in floodplains, on steep slopes, etc).
-Frequent need for road maintenance.
-Damage or needed repairs from small storm events.
-Undersized drainage structures.
-Critical transportation links between communities or areas.

Data Requirements:

-Road inventories.
-Hazard risk maps, if available.
-Qualitative field assessment of road conditions.

Output:

-An inventory of needed road work, by priority.
-Work lists developed for needed work (See Attached Work List forms)

-Documentation of measures and conducting training on measures useful to reduce road damage from disasters.

Results of Application at Case Study Site:

-Implementing road improvements to make roads more "storm resistant".
-Less frequent and less severe damage to roads (less plugged pipes and washouts, etc), less costly repairs, and less road closures.

Lessons Learned: See attached list of measures for reducing vulnerability of rural roads to natural disasters.

URL(s) or bibliographical references to/for publications about your case study:
Key references on this specific issue:

PIARC World Roads Association. 1999. Natural Disaster Reduction for Roads, Final Report 72.02B, Paris, FR. 275p.

Copeland, R.; Johansen, K. 1998. Water Roads Interaction: Examples from Three Flood Assessment Sites in Western Oregon. Report 9877-1805-SDTDC, San Dimas, CA. Technology and Development Center, U.S. Department of Agriculture, Forest Service. 15p.

De La Fuente, J. 1998. The Flood of 1997, Klamath National Forest. Unpublished Report, Yreka, CA. U.S. Department of Agriculture, Forest Service.

Rural Road Vulnerability Reduction Assessment, Mitigation Measures, and Training

By

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Summary

The US Forest Service has gained considerable experience in storm damage assessment and repair work over the past 30 years. Major storm damage repair programs have been undertaken in the western United States after the storm events of 1972, 1986, 1995, and 1997. Also considerable experience has been gained with road work throughout Central America after Hurricane Mitch and in the Caribbean after Hurricane Georges.

ASSESSMENT

Two levels of assessment have been used for road storm damage projects, depending on the scope of needed work and geographic extent of damage.

1. Program Prioritization of Roads (Large Area Assessment)
2. Project Road Work and Identified Mitigation Measures (Specific Existing Roads)

Program Priorities

Program Priorities are influenced by both Social and Physical considerations. Project selection has been based upon a subjective consideration of all priorities and factors, and the need to develop a balanced program of work.

Remember--**Long-term Programs Need Short-term Successes!**

Social Considerations

- Community Needs and Desires
- Community Involvement and Sustainability
- NGO support

Physical Considerations

- Watershed Priorities
- Road Use and Importance
- Feasibility of Desired Repairs
- Cost-Effectiveness

Project WorkPriorities

Project Work Priorities have typically been based upon road use and standard of the road. The most heavily used arterial and collector roads usually receive top priority and are repaired first and best. Secondary, local roads typically receive a lower priority. Road managers must have an inventory of or know their transportation system!

MITIGATION MEASURES

For any specific existing road or road system, a variety of planning and design tools are available to rural roads managers and engineers to help "storm-proof" a road and reduce the vulnerability of roads to natural disasters. A list of specific recommendations, or "Best Practices", is presented on the following pages (attached).

The work needed can be identified in the field on a work list, where the specific item, site conditions, and description of work, are listed by station or milepost along the road. See the attached Work List form and an example of a specific work list developed for a road project in Honduras after Hurricane Mitch. Most identified items of work involve improving roadway surface drainage to avoid water concentration and having well designed drainage crossings. Other common items of work include subgrade stabilization, slope treatments or needed retaining structures, and erosion control measures.

TRAINING

Over the past eight years considerable training has been conducted throughout Latin America on "Minimum Impact Rural Roads" and on the application of "Best Management Practices" to low-volume roads. The objectives of this training have been:

1. To improve basic road planning, design and construction, and repair techniques;
2. To discuss Environmental Analysis and reduce adverse environmental impacts from roads; and
3. To reduce the vulnerability of roads to natural disasters, particularly from storm events and flooding.

Work List Form

Road/Area____________

Station Or MP	Road Width m	Road Grade %	Cross-Slope %	Code	Work Description

Work List (Sample)

Road/Area--Desvio Sabana Hoyosa (Road P1T4)

Location, Station or MP	**Road Width m**	**Road Grade %**	**Cross-Slope %**	**Code**	**Work Description**
D1 (MP 0.0)					Intersection with P1 at Saddle
	4+1RL	0-18			Inslope Road to Ditch, Clean Ditch
D2					Install 24” Pipe & Drop Inlet, Drain Left
		11-12			Outslope Road, Reshape Rough Road Surface
D3 (MP 0.1)					Construct Dip, Drain Left
		3			Outslope Road
D4					Clean Existing Timber Culvert
		3			Inslope Road to Ditch
D5					Excavate Inlet Basin for Timber Culvert
	3.5+1RL	+3--3			Inslope Road and Reshape Ditch
D6					Replace Damaged Timber Culvert with an Armored Dip
		+3--3			Reshape Road and Ditch
D7					Construct Dip, Drain Left
		3 -5			Inslope Road, Reshape Ditch
D8 (MP 0.35)					Existing Timber Bridge Marginal—Eventually Replace with an Armored Ford
		7			Inslope Road, Reshape Ditch
D9					Replace Plugged Existing Timber Culvert With Culvert or Dip (Lower Grade 45 cm)
		2-10			Outslope Road and Construct 3 Dips, Drain Left
D10					Construct Dip, Drain Right
		10-16			Smooth Existing Roadway Alternative-Relocate Road between D10 & D11
D11					Construct Dip Left
		6			Outslope Road
D12 (MP 0.7)					At Gentle Saddle—Road OK
		2-5			Outslope Road, Construct 6 Dips between D12 & D13
D13 (MP 1.1)					Begin Ridgetop Road, Road OK

Measures for Reducing Vulnerability of Rural Roads to Natural Disasters

- Identify areas of historic or potential vulnerability, such as geologically unstable materials or areas, areas subject to flooding, or areas of high volcanic or seismic hazards.

- Avoid problematic areas and avoid road locations in areas of high natural hazard risk, such as landslides, rock-fall areas, steep slopes (over 60-70%), wet areas, saturated soils, etc.

- Avoid or minimize construction in narrow canyon bottoms or on flood plains of rivers that will inevitably be inundated during major storm events.

- Provide good roadway surface drainage and rolling road grades so that water is dispersed off the road frequently and water concentration is minimized.

- Minimize changes to natural drainage patterns and crossings to drainages. Drainage crossings are expensive and potentially problematic, so they must be well designed. Changes to natural drainage patterns or channels often result in either environmental damage or failures.

- Out slope roads whenever practical and use dip cross-drains for surface drainage rather than a system of ditches and culverts which require more maintenance and can easily plug during major storm events.

- Use simple fords or vented low-water crossings (vented fords) for small or low-flow stream crossings instead of culvert pipes that are more susceptible to plugging and failure. With fords, protect the entire wetted perimeter of the structure, protect the downstream edge of the structure against scour, and provide for fish passage where needed.

- Perform scheduled maintenance to be prepared for storms. Insure that culverts have their maximum capacity, that ditches are cleaned, and that channels are free of debris and brush than can plug structures. Keep the roadway surface shaped to disperse water rapidly and avoid areas of water concentration.

- Typically keep cut and fill slopes as flat as possible and well covered (stabilized) with vegetation to minimize slumping as well as minimize surface erosion. Well-cemented but highly erosive soils may best resist surface erosion with near-vertical slopes that minimize the surface area exposed to erosion.

- Use deep-rooted vegetation for biotechnical stabilization on slopes. Use a mixture of good ground cover plus deep-rooted vegetative species, preferably native species, to minimize deep-seated mass instability as well as offer surface erosion control protection.

- Locate bridges and other hydraulic structures on narrow sections of rivers and in areas of bedrock where possible. Avoid fine, deep alluvial deposits (of fine sand and silt) that are scour susceptible and problematic, or which otherwise require costly foundations.

- Design critical bridges and culverts with armored overflow areas near the structure to withstand overtopping, or have a controlled "failure" point that is easy to repair. Alternatively over-sizing the structure and allow for extra freeboard on bridges to maximize capacity and minimize risk of plugging. Also avoid constricting the natural channel.

- Insure that structural designs for bridges, retaining walls, and other structures include appropriate seismic design criteria and have good foundations to prevent failures during earthquakes.

- Place retaining structures, foundations, and slope stabilization measures into bedrock or firm, in-place material with good bearing capacity to minimize undermining, rather than placing these structures on shallow colluvial soil or on loose fill material.

Title:	**Multi-Peril Loss Studies: A Comparative Approach to Assessing Vulnerability in the Caribbean**

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Hazards examined: Earthquakes, hurricanes and combined perils.

Study emphasis: Post-disaster recovery, mitigation and risk management strategies.

Summary: Offers a methodology for comparing annual levels of risk between regions in the Caribbean. This is accomplished through the use of probabilistic loss calculations which provide loss estimations for a variety of hazard return periods on varying spatial scales. Results of the probabilistic loss calculations are applied to the formulation of Average Annualized Loss (AAL) estimations, devised by integrating losses from various disaster scenarios (possessing varying return periods and event magnitudes). Annualized Loss Ratios (ALRs) are the ratios of the average annual losses to the exposure to the hazard. ALRs for different areas may then be compared allowing for identification of levels of relative risk among different study locations. Study results are used primarily to establish insurance premium rates and assess industry solvency.

Vulnerability Indicators: Annualized loss ratios for earthquake, hurricane, and combined perils examined at various geographic levels of resolution (e.g. zip code to island/territory)

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: Prioritizing post-disaster recovery resource needs for various areas, developing a region-wide mitigation plan, and prioritizing regional risk management strategies based on the severity of the risk(s) and the risk drivers.

Data Requirements: Probabilistic hurricane and earthquake hazard models (including historical event databases, geologic data, wind field models, and underlying geography); structural type and occupancy classification systems; hurricane and earthquake vulnerability models

Output: Probabilistic loss calculations can provide loss estimates for a variety of return periods (e.g. 100 year loss) and at various geographic levels of resolution (e.g. zip code, city, county/parish, island/territory). An occurrence exceeding probability (EP) loss function uses a suite of scenario events to estimate the annual probability of exceeding a certain dollar loss. The

Average Annualized Loss (AAL) is an annual estimate developed by integrating losses from scenario earthquakes and hurricanes with varying repeat times and event magnitudes. This parameter provides a basis to compare the annual level of risk between regions. Risk management decisions however, should be based not only on absolute losses but should also take into account the exposure of a region. To deal with this issue, an Annualized Loss Ratio (ALR) is developed as the ratio of the average annual loss and the exposure. This index provides a measure of the relative risk between regions and can be compared across different geographic units.

The Caribbean loss study first compares ALRs for different islands/territories. These values are based on aggregated assumptions about city-level risk on each island. This study looks at ALRs for earthquake and hurricane perils, as well as the combination of both perils. A standard unit of $1,000 of residential exposure is used throughout the study region for purposes of comparison. However, the exposure assumptions vary from island-to-island to account for local building type variations. Next, the study compares risk at a higher level of resolution (i.e. zip code) for one territory, Puerto Rico. A representative residential exposure data set is used for this analysis so that variations in exposure and population density can also be assessed.

Results of Application at Case Study Site: Loss studies are commonly conducted for insurance regulators and industry associations. These studies provide a comprehensive profile of the peril-related risk(s) to the insurance industry in a particular region, state, or country. The results are usually provided in the aggregate (i.e. for the whole industry) as well as by individual company. These studies are generally used to establish premium rates, and assess industry solvency.

The Caribbean loss study illustrates relative risk based on Caribbean basin-wide hurricane and earthquake models developed in 1998. The outputs helped assess and validate model results, and communicate model implications with insurance and reinsurance clients. The Puerto Rico loss study is representative of results from an extensive model validation effort undertaken in 1999 based on losses incurred in Puerto Rico following Hurricane Georges. It is also indicative of results from an industry-wide study performed for the Puerto Rico Department of Insurance (1995).

Lessons Learned: Disaster management and policy decisions are risk-driven and thus require risk-based information. Yet, very often the “disaster vulnerability problem” is based on an understanding of the *hazard* (e.g. the location and type of faulting/geology or wind field models and storm tracks), rather than the *risk* (which results from a combination of the hazard, population and building exposure, and their respective vulnerabilities). A region with a high hazard level is not a societal concern if there is no exposed population and infrastructure. Contrarily, a low hazard area can experience high losses if there is significant exposure. Further, between two regions with the same hazard and exposure, the one with older and more vulnerable structures will suffer much more damage in comparable events.

Probabilistic-based loss studies provide a sound, long-term valuation of risk, and provide a good foundation for risk management policy making and mitigation investment. Peril models used in probabilistic analyses are generally well-validated, and based on accepted scientific evidence. The methodology is robust and results are generally stable, often with quantifiable uncertainty. A consistent and well-founded methodology provides decision makers with the means to measure the relative risk between perils, regions, and across different geographic units.

Title:	**Impact of an Earthquake on the Infrastructure of the Nicoya Peninsula, Costa Rica**

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Hazard examined:	Earthquakes (ground acceleration, liquefaction and landslide potential, permanent ground deformation)
Study emphasis:	Disaster preparedness, mitigation and recovery strategies.
Summary:	Offers a set of GIS-based maps detailing seismic hazards, typical soil profiles at selected sites and spatial distribution and degree of expected damage to infrastructure.

Vulnerability Indicators: Expected degree of damage

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: Identification of highly vulnerable sections of highways, critical bridges, schools and hospitals for disaster preparedness and rehabilitation plans to be executed by National Emergency Commission and Ministry of Public Works

Data Requirements: Maps (topography, geology), seismological parameters of sources, attenuation laws for chosen parameters, geotechnical and geophysical surveys, inventory and classification of exposed infrastructure, fragility curves for typical structures, acceleration records or intensities of previous earthquakes in the region, data of damage caused by previous earthquakes to similar infrastructure types

Output: Maps of seismic hazards (ground acceleration, liquefaction potential, landslide potential, permanent ground deformation, site effects) , typical soil profiles at selected sites, spatial distribution of expected damage on roads, bridges, schools and hospitals, lists of critical facilities with expected degree of damage, GIS with database of all roads, bridges and critical facilities for further use and display

Results of Application at Case Study Site: Maps of seismic hazards (ground acceleration, liquefaction potential, landslide potential, permanent ground deformation, site effects), typical soil profiles at selected sites, spatial distribution of expected damage on roads, bridges, schools and hospitals, lists of critical facilities with expected degree of damage, GIS with database of all roads, bridges and critical facilities for further use and display.

Note: Actual application of results of case study still in process by institutions involved in preparedness and rehabilitation of infrastructure.

Lessons Learned: Use of GIS is adequate for seismic hazard analysis but requires uniform quality of input. Uncertainties of data and estimations should be properly characterized by statistical parameters. Attenuation laws should be calibrated with local records of ground motion. For the case study, maps with scales 1:50,000 and 1:200,000 were suitable for modeling spatial distribution of ground motion but they were not optimum to clearly define zones of liquefaction and landslide potential. Methodologies for assessment of liquefaction and landslide potential should be improved. For assessment of site effects, separate studies of soil response have to be done before the results can be included in the GIS. Assessment of vulnerability of infrastructure requires a (laborious) thorough inventory of facilities, and their design and construction standards, and a careful selection of fragility curves. Fragility curves developed for other design and construction standards must be well adapted to local conditions (main shortcoming of methodology used) or calibrated with data from previous earthquake damage.

Organization of American States
Unit for Sustainable Development and Environment

Reduction of the Vulnerability of the Social and Economic Infrastructure to Natural Disasters in the Americas

Hemispheric Mandates
(Revision 14/05/01)

1. **Third Summit of the Americas**
   Quebec, Canada, April, 2001

Declaration of Quebec City
The Heads of State and Government of the Americas:

We commit to strengthening hemispheric cooperation and national capacities to develop a more integrated approach to the management of natural disasters. We will continue to implement policies that enhance our ability to prevent, mitigate and respond to the consequences of natural disasters. We agree to study measures to facilitate timely access to financial resources to address emergency needs.

Action Plan
8. DISASTER MANAGEMENT
The Governments:

Recognizing the need to develop, implement and sustain shared comprehensive disaster management strategies and programs to reduce the vulnerability of our populations and economies to natural and man-made disasters and to maintain or quickly restore minimum levels of consumption, income and production at the household and community levels in the aftermath of disasters, including irregular population settlements; acknowledging in this regard the need to expand the community of stakeholders at the regional, national and local levels engaged in the formulation of early warning systems, the management of risk and response operations in the event of disasters and integrated sustainable development strategies:

> Develop the capacity to forecast, prepare for and mitigate the potential impacts of natural and man-made hazards; promote vulnerability reduction; adopt and enforce better building codes and standards; ensure appropriate land-use practices; inventory and evaluate the vulnerability of critical facilities and infrastructure; estimate climate change variability and sea-level rise and assess their possible impacts; and in pursuit of the above, create the requisite legal framework and establish the cooperative mechanisms to access and share advances in science and technology and their application in the early warning, preparedness for and mitigation of these hazards;
>
> Promote the exchange of information on the vulnerability of infrastructure exposed to disasters as well as the early warning capacity, particularly in the border areas of the countries of the Americas, in order to design

specific prevention measures in the fields of engineering and legislation with the aim of reducing the socio-economic impact of natural disasters;

Establish or strengthen, where appropriate, partnerships with all relevant actors, including the private sector, technical professional associations, regional institutions, civil society, educational and research institutions and other multilateral coordinating agencies such as the Office for the Coordination of Humanitarian Affairs (OCHA), in the development and implementation of disaster management policies and programs at the national and community levels, and promote greater awareness and effective integration of these policies and programs among national policy makers, local authorities, communities and media, and promote the insurance and reinsurance of the social and economic infrastructure as well as the decentralization of information and decision-making;

Promote the exchange of knowledge and experiences regarding the combat against inappropriate practices in the exploitation of natural resources and unsustainable patterns of consumption, including the problems of waste management, which increase the vulnerability of the people to natural disasters;

Promote the development of telecommunications for humanitarian assistance; actively encourage greater use and interoperability of telecommunications and other technologies and information systems that allow the observation and monitoring of different natural phenomena; use early warning systems such as remote sensing imagery, Geographic Information Systems (GIS) based data necessary to address and prevent emergencies; promote the compatibility of these systems in the planning and response to emergency operations among governments, specialized agencies, relevant international organizations, and Non-Governmental Organizations (NGOs), and, in this spirit, consider signing and ratifying, ratifying, or acceding to, as soon as possible and as the case may be, the *Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations*;

Establish information networks with the involvement of the Inter-American Committee on Natural Disaster Reduction (IACNDR) and other relevant regional and international organizations to exchange scientific and technological knowledge and experiences; encourage further regional and subregional action to reduce risks and improve response to natural disasters; promote joint research and development technologies and contribute to strengthen coordination of national prevention and response agencies in natural disasters; to achieve this, draw on the work of ECLAC on the improvement, up-dating and implementation of its damage assessment methodology and continue to promote natural disaster mitigation and risk reduction awareness and preparedness;

Consider the creation of a hemispheric system for prevention and mitigation of disasters that would include, among others, a specialized database containing the best information available on the characteristics, experiences, strengths and weaknesses of national and regional agencies responsible for disaster prevention and mitigation and provide a new framework for technical cooperation and research aimed at creating a hemispheric culture of prevention and solidarity;

Adopt and support, as appropriate, initiatives aimed at promoting capacity building at all levels, such as the transfer and development of technology for prevention – risk reduction, awareness, preparedness, mitigation – and response to natural and other disasters, as well as for the rehabilitation of affected areas;

Promote mechanisms that incorporate risk management and risk reduction methods in public and private development investments;

Convene within a year a hemispheric meeting on disaster preparedness and mitigation with the support of the IACNDR and the participation of a wide range of government entities, regional and MDBs, private entities, NGOs and the research, scientific and technical communities, to discuss and develop cooperative efforts to facilitate implementation of Summit mandates on disaster management;

Request the IDB to undertake a feasibility study in partnership with the OAS, the World Bank, the Caribbean Development Bank (CDB) and other relevant inter-American organizations, as well as the private sector, including insurance companies, on measures to reduce and/or pool risk in a manner that results in reduced premiums on catastrophic insurance, and mechanisms to facilitate contingent re-construction financing and the immediate release of funds to resolve urgent needs of the affected country; this study would examine the relationship between re-insurance and national and community disaster management capacities, as well as trends toward dis-investment and job losses in those economic sectors requiring costly catastrophic insurance coverage and the role such measures might play in this regard; share with the private sector experiences in the development and application of risk management tools such as risk transfer instruments, vulnerability assessment methodologies and risk reduction incentives for the private sector;

2. **OAS/General Assembly**
   OAS Natural Disaster Reduction and Response Mechanisms
   Resolution AG/RES. 1682 (XXIX-0/99)

   Creation of the Inter-American Committee on Natural Disaster Reduction chaired by the Secretary General of the OAS and as members the Chair of the Permanent Council of the OAS, the Assistant Secretary General of the OAS, the President of the Inter-American Development Bank (IDB), the Secretary General of the Inter-American Institute for Cooperation on Agriculture (IICA), the Director General of the Pan American Health Organization (PAHO), and the Secretary General of the Pan American Institute for Geography and History (PAIGH).

3. **Bolivia Summit Conference on Sustainable Development**
   Action Plan for the Sustainable Development of the Americas
   Santa Cruz de la Sierra, Bolivia, December, 1996

Initiatives for Action
The governments will complete the following initiatives:

Initiative 6. Promote the inclusion of …mitigation in national development plans…and promote the establishment of appropriate construction codes that include regulatory and enforcement mechanisms through the sharing of technical information and expertise.

Initiative 43. Promote the exchange of information and experiences among the mayors of the Hemisphere regarding the most appropriate practices for urban environmental stewardship, promotion of non-polluting consumer practices, sustainable transportation, environmental impacts and sewage treatment.

Initiative 45. Foster the inclusion of sustainable development in the plans for urban development, including mechanisms for evaluating environmental impacts.

Initiative 57. Cooperate in the development, strengthening and implementation of pollution prevention programs and regional disaster plans, including contingency and response arrangements to combat the impact on water sources, oil spills and other forms of pollution which have an impact on water sources.

4. Second Summit of the Americas
Action Plan
Santiago, Chile, April, 1998

III. Economic Integration and Free Trade
The Governments:

- Will apply the mechanisms of science and technology in order to mitigate the damages caused by the effects of "El Niño" and other natural disasters, such as volcanic eruptions, hurricanes, earthquakes and floods, and the impact on the economy and on the ecosystems, based on a better capability for prediction, prevention and response; better investigation and methods of training for the prediction of natural disasters; and the application of science and technology to confront the effects of climate change on health, agriculture and water. In this sense, they will emphasize the cooperation in investigation and the exchange of information regarding "El Niño" and other natural disasters.

5. Inter-American Program for Sustainable Development
OAS/Inter-American Council for Integral Development (CIDI)
(CIDI/doc. 11/97, April 8, 1997)

III. Objectives

In order to comply with the mandates of the Summit of the Americas (Miami, 1994) and the Summit of the Americas on Sustainable Development (Bolivia, 1996), and to make a significant contribution to the implementation of Program 21 and to the fulfillment of other agreements produced by the Rio Conference and by that on Sustainable Development of Small Island Developing States, the OAS will give priority to:

a. Serving as a hemispheric forum for promoting dialogue and coordinating advances in the area of sustainable development.

b. Supporting the exchange of information on matters relating to sustainable development and facilitating the direct exchange of experiences among countries, institutions and organizations that are working in these areas.

c. Acting as a partner in cooperation matters relating to sustainable development in areas where it has comparative advantage.

IV. Priority Activities at the Sectoral Level

4.2 Sustainable Agriculture and Forestry

The OAS will take the following actions in this area:

a. Serve as a regional forum for:

iii) Facilitating the adoption of agreements, strategies and integrated politics, in coordination with other institutions like the IICA, UNDP and FAO, to address the needs of access to, transfer of, and incorporation of appropriate production technologies and sustainable management of the natural resources in our region, as well as improving the quality of life of the poorest rural segments of society. Special emphasis should be given to the zones and countries affected by processes of desertification, within the framework of the United Nations Convention to Combat Desertification.

c. Promote cooperation for:

iv) Strengthening activities in support of the development of environmental legislation on biodiversity protection and combating desertification, and, in particular, of standards that will facilitate conservation and the sustainable use of natural resources and ecosystems that are shared between countries or groups of countries, at their request.

4.3 Sustainable Cities and Communities

The OAS will take the following actions in these areas:

a. Serve as a regional forum for:

ii) Holding Inter-American technical meetings and promoting dialogue on reducing the vulnerability of the social and economic infrastructure to the impacts of natural disasters and environmental hazards.

c. Provide cooperation for:

ii) Supporting the planning and training needed to protect people and infrastructure from vulnerability to the impacts of natural disasters and environmental hazards, with a particular focus on water, health, electricity and transportation services, schools and housing, including the preparation of environmental impact studies and appropriate construction standards.

4.4 Water Resources and Coastal Areas

The OAS will play a leading role in helping countries to implement the Plan of Action of Santa Cruz in these areas. For this purpose, it will work in coordination with UNEP, the World Bank, the IDB and UNDP, and will take the following actions:

a. Serve as a regional forum for:

v) Supporting mechanisms for inter-institutional dialogue and cooperation in the preparation by the member states of vulnerability profiles for small island states and threatened coastal and inland water systems.

c. Provide cooperation for:

v) Executing multinational project and investment plans for the sustainable use of coastal resources, particularly in activities related to tourism development, poverty alleviation, and the reduction of the vulnerability of communities and their infrastructure to natural hazards.

vii) Taking into account climate change, identify mechanisms to assist the most vulnerable states, in particular island states and member countries with low-lying coastal areas, in their efforts to adapt to economic, social and environmental impacts and to reduce their vulnerability to natural hazards, including the use of inventories, dissemination of information, legislation, institutional strengthening and public awareness campaigns.

6. Inter-American Dialogue for Disaster Reduction
Dialogue I, Conclusions
Panama, December, 1997

7. Hemispheric Congress on Disaster Reduction and Sustainable Development
Act of Congress
Miami, October, 1996

8. **Inter-American Conference regarding the Reduction of Natural Disasters**
   Declaration
   National Experiences, Preparatory Forum for the IDNDR World Conference
   Cartagena de Indias, Colombia, March 21-24, 1994

9. **OAS/Inter-American Economic and Social Council**
   Natural Disasters

<u>Resolution CIES/RES. (862/93)</u>

10. **OAS/Inter-American Council for Education, Science and Culture**
    Support for the International Decade for Natural Disaster Reduction

<u>Resolution CIECC/RES. (862/93)</u>

11. **OAS/Permanent Council**
    Support for the Theme "Natural Disasters Reduction for Sustainable Development" of the World
    International Decade for Natural Disaster Reduction Day 1992
    Resolution CP/RES. 593 (922/92)

12. **OAS/Permanent Council**
    Participation by the Organization of American States in the International Decade for Natural Disasters
    Reduction
    Resolution CP/RES. 546 (834/90)

Title:	**Human Safety and Regional Development: A Peruvian Experience**
Contact(s):	Name: Julio Kuroiwa Agency: OAS, USDE Phone: None Fax: (202) 458-3560 E-mail: None
Hazards examined:	Earthquakes, floods
Study emphasis:	Economic development, vulnerability assessment and reduction, land use planning and hazard/disaster mitigation strategies.
Summary:	Offers a city and expansion areas hazards map detailing all potential natural disaster scenarios within the areas of interest (ranking each as high, medium or low). Study stresses careful and prudent land-use planning toward the goal of fostering disaster resistant and sustainable development practices. Main goal of the study is to prevent the occupancy of highly hazardous areas for urban settlement purposes.

DEVELOPINC COUNTRIES CITIES ARE INCREASINGLY VULNERABLE TO INTENSE NATURAL EVENTS.

Because of the explosive population growth in developing countries, poor people in large cities are occupying with increasing frequency, marginal and highly hazardous sectors, where they build vulnerable dwellings resulting in a very high risk for their occupants. Since no effective action has been taken to reverse such a worrisome situation, disasters in the next century may be even worse than today's (Kuroiwa, 1995).

Earthquakes and floods are the two most frequent threats to people. The Colombia, Quindio Earthquake of January 1999, and The El-Niño effects in Ecuador and NW Peru in 1998 are two recent examples. The flooding hazard map of the main cities of Peru's N-W coastal region were drawn in 1998. As may be expected, the flooded sectors were, with minor differences, the same as those affected during the 1982-83 El-Niño. The knowledge and tools to develop sound urban centers exist (Kuroiwa et.al. 1978), (Kuroiwa, 1982), (Kuroiwa & Alva, 1991), but political decisions on the part of the central and local authorities are necessary.

ACTIONS TO REDUCE RISK IN URBAN CENTERS

In. I 995, at mid-IDNDR, it became clear that to reduce risk in urban centers much more needed to be done than developing practical useful theses on microzonation in the universities academic exercises. The political decision of the central and local governments to develop safe cities and to provide the necessary funds are absolutely necessary.

We were having a hard time getting the authorities to listen, then the 1997-98 El Niño occurred, and eventually caused about two billion USD in direct losses. The worst-hit area was again Peru's N-W region near the border of Ecuador where the Inter-Tropical Convergence Zone--ITCZ displaced south from its usual location north of the Equatorial line The lakes which provided water for the Panama Canal were almost empty but in Ecuador and northern Peru there was torrential rain. The 1982-83 El Niño also caused direct losses of some two billion USD, but the consequences remained for years because the productive facilities of N-W Peru were completely disrupted including the Panamerican Highway and other roads. The irrigation canals remained out of service for a long time, so the indirect losses were also huge.

Based on that negative experience of the previous catastrophic event, and the fact that El Niño indicators had shown that a large event was incubating. The El Niño-Southern Oscillation - ENSO had shown negative values and the abnormality of the Superficial Sea Water Temperature – SSWT was unusually high, which could by obtained by from NOAA/Internet. the Peruvian Government took a series of preventative actions during the second semester of 1997 and early 1998 to reduce the impact of El Niño. These measures where taken under the leadership of the president Mr. A Fujimori.

CEREN- The Executive Committee of Reconstruction of El Niño with is headed by the then prime minister Mr. A Pandolfi who continues as chief of CEREN, was appointed Minister of Transportation, Communication, Housing and Construction - MTC to be directly involved in the reconstruction task of the most affected sectors. In September 1998, by mutual approach, Mr. Pandolfi nominated the author as ad-honorem adviser of CEREN.

In November 1998, the author proposed to CEREN the development of Sustainable Cities I Stage which was accepted. At the same time the United Nations Development Program - UNOP that was already assisting CEREN approved its participation in the Program. At present this CEREN-UNDP program is being developed jointly. This requests from mayors of the places that were hardest hit by the 1997-98 El Niño to participate in the program have surpassed the capacity of the working group, so the necessary and important participation of the local universities in the program implementation has been agreed in a public ceremony held in Piura, Tumbes and Ica during the first semester on 1999.

SUSTAINABLE CITY DEVELOPMENT - SCD. FIRST STAGE-IS, SCD-1S

We define a sustainable city as one which is safe, orderly, healthy, attractive and efficient, in its function and development. If we are able to develop such a type of city, we can leave to the future generations sound urban centers, where the inhabitants will not have to suffer a drastic reduction in their standard of living because of an intense or extreme natural event. It is a very difficult task to implement, especially in Third World countries, but not impossible. In the long range, this may be another important task for the century starting in the year 2000.

In its first stage the objective is more modest: to reverse the increasing risk of the important cities of developing countries located in natural disaster-prone regions. As has been stated, the knowledge to do so already exists, and the decision to go ahead has been taken at the highest political level and also by local level authorities in Peru. This an opportunity and a challenge to succeed.

Approach of the SCD-1S

The strategy for success in group A, which includes 10 cities, is that the program is comprehensive, simple to apply and the process of approval of land-use planning results involves the conscious active participation of the citizen. The selected cities were severely affected by El Niño 1982-83 and 1997-98, except Ica was hit only by the last event. So the city mayors and the communities are highly motivated.

All the mayors have had working meetings with the CEREN - UNDP Working Group. They have readily requested to participate in the Program. Large municipalities such as Piura and Tumbes are also providing their own funds and have set up working groups.

The steps of the programs with some commentaries are as follows:

a) Initiative of the city mayor. Request to CEREN-UNDP to participate in the Program, which has already bean made by all the mayors of Group A cities.

b) Program formulation for each city according to a model developed. The program has already been formulated and field work is underway. Some cities have already concluded this portion.

e) Preparation of city and expansion areas hazard map. This is a simplified microzonation map. Six of the cities have microzonation investigation results in which the flood hazards have been drawn by the Nature in 1983 and 1998. The study includes all natural phenomena threatening the area of interest. The respective professional theses were developed at the Japan-Peru Center for Earthquake Engineering Research and Disaster Mitigation - CISMID/FIC at the National University of Engineenng UNI: CISMID FIC/UNI, Lima, Peru. The University of Piura and the National University of Piura are reviewing and improving previous investigations and will develop the studies for 3 new cities. The study for the city of lca was jointly made by CISMID FIC/UNI and the National University of Ica.

d) Land-use planning. Most of the plans are the responsibility of the National Institute of Urban Development - INADUR of MTC, but some private consultants are also participating. The Ica plan is in the hands of a local architect who developed her masters degree thesis at the graduate School of Architecture of the National University of Engineering, Lima.

e) Construction type selection, according to the characteristics of each hazard sector. (Please see comments, below).

f) Approval process: City Council (Provisional) -- Professional Associations -- Public Assembly -- City Council (Final).

g) Municipal Ordinance. The model ordinance in which all legal problems have been solved is ready.

h) Institutional strengthening of the participating municipalities to improve the municipal control.

The main aim of the Program is to prevent occupancy of highly hazardous areas for urban purposes. The geologists and architects have been especially advised to delimit such sectors carefully, for designation as ecological reserves and recreational areas.

The highest degree of hazard is “exceptionally high”, where the force of Nature is so strong that no man-made construction is able to take. For example the Huascaran avalanche during the 1970 Peru Earthquake which released 80 million tons of snow, mud and very large rocks. In sectors belonging to this category urban development is not permitted under any circumstances. In the cities under consideration, there are only a law areas in this category. Most of the cities have sectors of “high”, “medium” and “low” hazard.

Sectors included in the category of high hazard are, for example, areas which are flooded at low velocity, or soil consisting of aeolian sand. Earthen constructions are not permitted in either of these cases. Such constructions are highly vulnerable when under water for several days. Also, on aeolian sand, settlement and high seismic intensity is expected, which cannot be supported by the heavy, weak adobe construction. Lightweight materials such as wood and bamboo have behaved well in past earthquakes, including in Armenia, Colombia, in January 1999.

The experience of recent past disasters, such as the El Niño 1997-98 Is being taken into account. For example, San José, in the lower park of Tumbes, has been flooded several times. All adobe constructions have gone, but brick and wood and bamboo buildings have remained standing, with minor damage only A special manual is being prepared with a guide to suitable construction materials and methods, and the soil coefficient of the new 1997 Peruvian Seismic Code to be applied in each sector.

SUMMARY OF RESULTS

As of December 1999, 3 out of the 10 participating municipalities in the CEREN-UNDP Program SCO-IS have concluded the land use planning for disaster mitigation. The approval process of 2 of them is underway. It is expected that the respective municipal ordinance will be promulgated by the end of 1999. The process of the remaining 8 municipalities is to be concluded during the first semester of the year 2000. Some 10 additional cities will participate in Group B during that year.

CONCLUDING REMARKS

The method used in the development of the SCD-1S is action-oriented, simple and cheap to implement uses existing data, complemented by key field investigation. Mayors with different political tendencies ire enthusiastically participating in the Program SCD-IS as everybody wins, and good progress is being made.

It was possible to advance very quickly in 6 of the cities in Group A, because the microzonation investigations were made from 1989 to 1992 as part of Peru’s program for the IDNDR. They are located in the Grau region with an area of 41,000 Km2 and some 2 million inhabitants. The selected cities were prioritized according to their importance and population growth rate and known physical safety problems.

Investigation was made for professional theses of civil engineering graduates at CISMID/FIC-UNI under he sponsorship of JICA. The UNCRD organized an international seminar on regional disaster mitigation held in Piura in 1991, to share this experience with participants from some 15 Latin American countries. This is only the first step on the long road to developing sustainable cities in Peru, but it tackles one of the most critical problems: human safety.

The experience of the World Bank In South East Asia, India and Turkey in developing integrated urban infrastructure and effectively handling the necessary funds from different sources, will be very useful for improving the Peruvian cities economic competitiveness in the globalized world of today and tomorrow. It will help to strengthen the administrative capability of the municipalities and assist them in prioritizing the construction of infrastructure that is urgently needed, is cost effective and is to be executed soon, but looking ahead to the medium and long range objectives.

In the Third Country Seminars, organized by CISMID/FIC-UNI and guided and funded by JICA for about 10 years, some 50 professors from regional universities have participated. Emphasis was given to microzonation and its application to urban and regional planning for disaster mitigation. So what needed is political decision on the part of local authorities of most of the important Peruvian cities to implement similar programs in order for the ongoing SCD-1S, to really have national impact in reducing risk in Peruvian urban centers.

Another important advancement is the fact the National institute of Urban Planning-INADUR has decided not to develop any urban planning without taking into consideration disaster reduction measures in all future programs.

The USC-IS is being reported to the international community as part of the Peru's program for the IDNDR as of June, 1999 (Kuroiwa, 2000), but does not include the progress of the 1999 second semester.

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Title:	**Hazard Vulnerability and Consequence Analysis: Building Sustainable Communities**	

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Hazards Examined: Multi-hazard

Study emphasis: Vulnerability Analysis, Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: An assessment of the impact of a hazard on a community provides information on the immediate consequences of a hazard event. The capacity of a community to recover from a disaster is a reflection of social, economic, and environmental indicators. Communities with high unemployment, environmental contamination, and social problems are at a significant disadvantage to respond and recover from a disaster. Communities with a stable transportation, utility, and communication infrastructure are in a far better position to cope with disaster. Effective disaster response is based on strong educational, health, political, and social systems. Communities that are experiencing economic crisis, social disorder, and political unrest may find it difficult if not impossible to cope with disaster. An understanding of the nature and characteristics of hazards and disasters is essential to the short and long term sustainability of a community.

Vulnerability Indicators: Unemployment Rate, Crime Rate, Pre-mature Birth Rate, School Drop-out Rate, Average Income, Recreation to Population Ratio, and Autos to Population Ratio

Data Requirements: Employment, Census Bureau, education, parks and recreation, health care, and economic data.

Output: Community Profiles reflecting social, economic, and environmental indicators.

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

http://www.risk.lsu.edu

Title: **UC Berkeley Seismic Vulnerability Study – Berkeley, CA**

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Hazard examined: Earthquakes

Study emphasis: Risk management and recovery strategies.

Summary: Offers a loss estimation methodology, based upon three separate categories of earthquakes, useful in determining the degree of destruction and expected losses in dollars to university structures and contents, including anticipated downtimes for buildings and corresponding economic impacts (to both the university and the surrounding community).

Vulnerability Indicators: structural collapse, nonstructural damage, potential deaths and injuries, serviceability after event

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: to be used for risk management purposes: setting priorities for structural and nonstructural retrofits, for business resumption plans, and for recovery strategies

Data Requirements: microzonation soil map; seismic-geologic hazards; ground shaking estimates; conditions of structures, nonstructural elements, and utilities; usage and occupancy data; and financial info on income streams and expenditures

Output: The UC Berkeley loss estimation produces information on the probable condition of the 114 structures on the central campus following three categories of quakes. The categories are: Occasional (50% probability of exceedance in 50 years; on any Bay Area fault); Rare (10% probability of exceedance in 50 years; on the northern Hayward fault); and Very Rare (5% probability of exceedance in 50 years; on the northern Hayward). It produces information on the expected losses in dollars to structures and contents. It yields estimates of expected downtimes for buildings, and the corresponding economic impacts (to the university and the community surrounding the university) of short and long-term closures of all or part of the university.

Results of Application at Case Study Site:

1) conservative estimates for repairs and replacements (structures and contents) range from $600 million to $2.6 billion, depending on the severity of the quake.

2) In a Rare quake, 40%-60% of campus space would be damaged enough that 20 months or more would be required for repair and reopening.
3) The damages would be structural and nonstructural
4) The impact of university closure would be significant on Berkeley economy, but less marked in the total Bay Area.
5) Interruption of research would have deleterious effects on current projects and on prospects for future funding.

Lessons Learned:

A) Beyond the obvious vulnerability of buildings rated "poor" or "very poor," structures rated "fair" could incur significant structural and nonstructural damage, and be closed for lengthy periods
B) 75% of research funds ($400 million/year) are spent on projects in only 17 buildings on the main campus, many of which range from "very poor" to "fair." This indicates a concentrated vulnerability of research.
C) One-third of the replacement value of the campus is in contents (books, art, anthropology artifacts, research materials, highly technical equipment, and computers). Serviceability after a quake will involve repairing or quickly replacing materials, equipment, and computers.
D) Obviously, retrofitting buildings for life safety will not guarantee their functionality after a quake.
E) Similarly, structural retrofits that pay no heed to nonstructural hazards guarantee neither 1) life safety when there are nonstructural damages, nor 2) functionality following an earthquake
F) Retrofit priorities should change in light of A&B, especially, above.
G) Business resumption planning is critically important to the ongoing operations of the university following a quake.

Title:	**Evaluation of Erosion Hazards – United States shoreline (Atlantic, Gulf, Pacific and Great Lakes)**
Contact(s):	Name: Steve Dunn Agency: The Heinz Center 1001 Pennsylvania Ave, NW Suite 735 South Washington, D.C. 20004 Phone: (202) 737-6307 Fax: (202) 737-6410 E-mail: sdunn@heinzctr.org
Hazard examined:	Coastal erosion
Study emphasis:	Economic development, land use planning in coastal areas, setting flood and erosion insurance premium rates and cost effectiveness of shoreline protective measures.
Summary:	Offers a set of policy options reflecting a range of possible responses to erosion hazards including, but not limited to, creation of coastal high hazard zones, surcharges on flood insurance and/or regulatory measures for current and future structures located within erosion zones, erosion insurance and relocation assistance and/or land acquisition and shoreline protective measures.

Vulnerability Indicators: Property (land, buildings) within 60-year erosion hazard areas

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: Land use planning in coastal areas, setting flood and erosion insurance premium rates, cost effectiveness of shoreline protection measures.
Data Requirements:

The study was conducted in three phases. In phase 1, the Federal Emergency Management Agency contracted with state agencies to produce maps for 27 counties along U.S. coastlines to map the following features:

- 60-year EHAs, calculated by multiplying erosion rates at each site by 60 years;
- Current Flood Insurance Rate Map (FIRM)-based flood zones, including V-zone/A-zone boundaries and some A-zone/X-zone boundaries, both with associated base flood elevations (BFEs) and gutter lines (i.e., contour lines within flood elevations that separate areas with different BFEs); and
- 60-year projected FIRM-based flood zones. These zones were determined by projecting the current FIRM-based flood zones landward by approximately the distance that the beach is expected to erode during the next 60 years (i.e., the width of the 60-year EHA).

The Heinz Center conducted phases 2 and 3, which included a field survey of over 10,000 structures and analyses of the extent of erosion-related damage and options to address that damage.

Using the 60-year projected erosion hazard zones, the number of structures in each EHA was approximated for all 27 counties. The Heinz Center's subcontractor, Spatial Data Institute, conducted field survey measurements of 11,234 structures in or near 60-year EHAs. Because of cost constraints and the limited availability of assessment data on structures, field surveys were conducted in only 18 of the 27 counties (see Figure 1.). All geographic regions of the United States were represented in the study.

Structures were sampled within representative sampling transects distributed throughout the entire length of mapped coastline.[1] The transects included both eroding and non-eroding areas, as well as varying flood heights and zone designations (e.g., V-zone, A-zone, and X-zone). Using the Global Positioning System and conventional survey techniques, the surveyors located the latitude and longitude coordinates of each structure accurate to within 3 feet and the vertical elevation of the lowest floor accurate to within 6 inches.

Detailed structure and parcel attribute information was obtained from each local government's tax assessment office. This information was combined with the field survey data and plotted on the 60-year EHA maps in a geographic information system.

The NFIP policies in force and claims data from the Federal Insurance Administration for the 27 counties mapped by FEMA also were obtained. Detailed property attributes, such as sales price and interior features, were acquired through a mail survey of owners of field-surveyed properties. Finally, a database of coastal erosion rates and census block groups adjoining open-ocean coastlines nationwide was developed to extrapolate nationwide erosion losses and the effects of policy changes on the NFIP and coastal communities.

[1] Two counties, Sussex, DE and Glynn, GA**,** were selected as pilot tests for the field survey work and were sampled in their entirety.

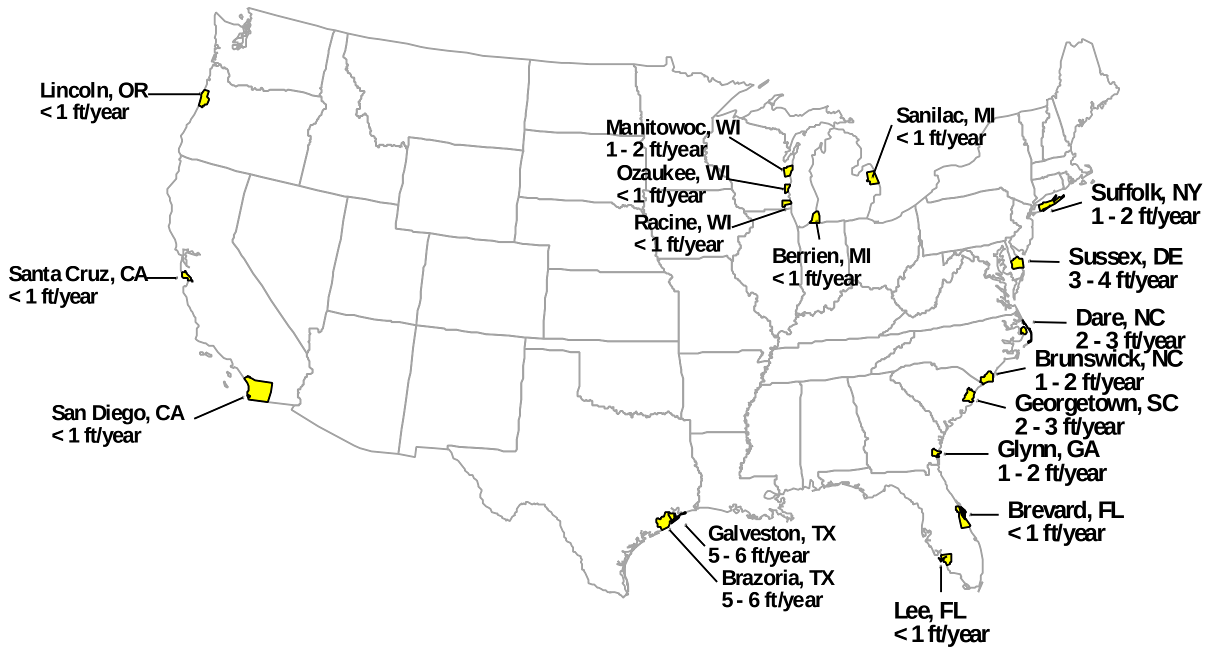

FIGURE 1. Counties studied in evaluation of erosion hazards and average annual erosion rates (feet/year).

Output: The Heinz Center focused on analyzing the impacts of erosion and the effects of policy changes on the NFIP and coastal communities. The economic impact analysis included two major components: estimates of the impacts of erosion and evaluation of the impacts of possible changes in the cost and availability of flood insurance within the mapped EHAs. The first component answers the question, “How big a problem is coastal erosion?” The second component develops the “building blocks” needed to address the options suggested by the U.S. Congress in Section 577. The analysis of the impacts of erosion considered the following elements:

- value of the structures damaged by erosion,
- National Flood Insurance Fund (NFIF) compensation to policyholders for erosion-related flood losses, and
- changes in the value of residential and commercial properties in communities with erosion hazards.

The following set of policy options or “packages” (some dependent on mapping and others not), reflecting a range of possible responses to erosion hazards as broadly defined by Section 577, were evaluated:

1. maintain the status quo (i.e., no change in policy);
2. erosion mapping and dissemination alone;
3. creation of a coastal high hazard zone, including both high flood and erosion zones;
4. mandatory erosion surcharge on flood insurance in erosion zones;
5. erosion surcharge combined with regulatory measures to reduce damages;
6. flood-related regulatory changes in erosion zones;
7. erosion insurance in bluff areas susceptible to erosion but not flooding;
8. relocation assistance and/or land acquisition; and
9. shoreline protection measures (i.e., nourishment, dune restoration, and structural measures).

For each of the eight policy alternatives to the status quo, the three types of economic impacts listed above were evaluated and compared with the impacts of erosion under current policies and management regimes.

Results of Application at Case Study Site: The final report will be submitted to FEMA and Congress in Spring, 2000. Findings will be disseminated to coastal zone managers, researchers, policymakers, and the interested public through participation in conference workshops, popular magazine articles, and electronic communications.

Lessons Learned: The dynamic nature of the shoreline makes it difficult to accurately assess a community's risk and vulnerability. Extreme storm events can cause rapid, episodic erosion that can move the shoreline hundreds of feet inland, followed by an extended period in which the beach accretes back, but not completely, to its former position. These episodic events can greatly increase a community's risk of damage. Further, future projections of shoreline position reflect past sea level rise, but do not reflect future rates of sea level rise, which may accelerate because of global climate change. Conversely, communities respond to the erosion hazard by constructing shoreline protection projects (e.g., beach nourishment, seawalls, dune restoration), thus lowering their vulnerability.

Title:	**Social Vulnerability Assessment in Mexico City and Los Angeles**	
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Hazard examined:	Earthquake, landslide, flood, fire, explosive and chemical hazards	
Study emphasis:	Disaster preparedness and risk identification (based upon various population dynamics, namely immigration status, ethnicity, income, gender, age, health status and housing type and location).	
Summary:	Offers a compilation of maps that superimpose vulnerable populations with the physical hazard. Maps and lists are provided which identify municipalities in metro regions with high percentages of vulnerable people. Also, a catalog of "best practices" of conducting detailed vulnerability assessments, supplementary local hazard mapping and preparedness training was developed. Training courses were developed and presented based upon these products.	

<u>Vulnerability Indicators:</u> (1) Immigration status (rural/urban, international/domestic, legal/illegal); (2) Income, gender, age, ethnicity (esp. low income elderly, low income single mothers, low income minorities/indigenous; (3) Health status; (4) Housing type (esp. engineered vs. self-built, sheltered vs. homeless (including street children); (5) Location (esp. squatter settlements).

<u>Applications:</u>
ECONOMIC DEVELOPMENT: No application or impact so far; however, in principle the thorough inclusion of social vulnerability data in plans -- especially since much of it is gathered and updated in a partnership with citizen -- based organizations -- should lead to more citizen pressure for economic development policies that explicitly take disaster mitigation into account.

DISASTER PREPAREDNESS: Applications in the area of risk communication (Los Angeles: electronic and print communication in numerous languages, outreach to specific groups such as homeless youth and elderly living in mobile homes; Mexico City: new formal links with citizen-based organizations).

DISASTER RESPONSE/RECOVERY: Too soon to tell; however the decentralized community emergency response teams (CERT) are said to have functioned well in the Northridge earthquake, providing local knowledge including presence of persons with special needs and at risk because of age, health status, disability, etc.

Data Requirements: (1) Detailed hazard maps (sub-municipal scale/ microzonation): earthquake, landslide, flood, fire, explosive and chemical hazards; (2) Population census data; (3) Sample household socio-economic data; (4) Municipal agency data: health, social services, housing, emergency response, mitigation, and recovery resources; (5) NGO/ church/ voluntary agency data: health, social services (esp. re: children, elders, homeless, immigrants, minorities), community resources for emergency response, mitigation, and recovery.

NOTE: The key to success is INTEGRATION of social vulnerability with physical hazard data and response/resource data. This requires inter- and intra-agency ACCESS AND SHARING of data. It also requires an INTERDISCIPLINARY approach and common PLATFORM (GIS, municipal data book and maps, standing health and safety committee) to ensure ACCESS, USE, UPDATING and CONTINUITY or INSTITUTIONAL MEMORY. None of this is easy, especially inter-agency sharing that involves municipal and non-governmental institutions. TRUST must be established between such agencies.

Output: (1) Maps that superimpose vulnerable populations and physical hazard; (2) Maps and lists identifying municipalities in metro regions with high percentage of highly vulnerable people; lists of neighborhoods at highest risk (RISK = [VULNERABILITY X HAZARD] – [MITIGATION + RESPONSE CAPACITY]); (3) Catalog of "best practices" at municipal and neighborhood level of "bottom up" vulnerability assessment, supplementary local hazard mapping, and preparedness training; (4) Training courses based on all of the above.

NOTE: These outputs have influenced municipal level decisions concerning risk communication, preparedness training, partnerships with NGOs, and NGO cooperation with municipal agencies. REMAINING CHALLENGES: (1) Bring ALL municipalities up to highest level of community participation and preparedness attained by the BEST; (2) Extend use of such vulnerability assessment to decisions/regulative activity concerned with industrial location and plant operation, land use, infrastructure and service investment.

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von Kotze, A. and Holloway, A. (1996) Reducing Risk: Participatory Learning Activities for Disaster Mitigation in Southern Africa. Durban and Geneva: Department of Adult and Community Education, University of Natal and IFRC [Distributed by Oxfam UK].

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Results at Site:

GREATER LOS ANGELES: Variable with good cooperation between municipalities and NGOs in some municipalities (e.g. West Hollywood, Santa Monica) and not in others. Planning for emergency needs of elderly, people living with AIDS, non-English speakers, etc. in many municipalities, while plans for illegal immigrants, immigrant day laborers, and some low income minority groups lag behind. City of Los Angeles has ambitious community volunteer training program for emergency response, reaching 20,000 people, but low income people and minorities are not well represented. Some NGOs are continuing to lobby with municipal government about hazards that concern citizens (e.g. ACLU in San Pedro re: LPG terminal under construction in San Pedro harbor).

Finally, at several of the 28 municipalities samples, there is increased discussion between city agencies and NGOs and increased awareness of the necessity to integrate social data into mitigation, response, and recovery plans.

MEXICO CITY: Training and community based vulnerability assessment institutionalized through CENEPRED, Mexico's National Center for Disaster Prevention, which has social science advisory council. Community and NGO liaison institutionalized through Mexico City's Office of Emergency Services. Little success however, in including land use planners and other city planners in the effort. The political difficulty of evicting illegal squatters even from very dangerous sites will continue to be a major challenge to "mainstreaming" vulnerability assessment. Some NGOs have become strong, highly institutionalized advocates for "mainstreaming" (e.g. post-1985 earthquake citizen-based re-housing and recovery organization CARITAS).

NOTE: The social vulnerability assessment methods tested in greater Mexico City and greater Los Angeles as well as the other four large urban regions covered by the UNU project have been further disseminated to the nine core IDNDR-RADIUS cities (including Tijuana, Guayaquil, and Antofagasta in this hemisphere) and to the cities associated with the Earthquakes and Megacities Initiative (EMI), including, in this hemisphere as cluster constituted by Mexico City, Los Angeles, Bogota and Quito. Finally, these methods have been integrated in the forthcoming FLACSO-La Red curriculum for the internet-based master's degree program on disaster management.

<u>Lessons Learned:</u> The development of methods for assessing social vulnerability in greater Los Angeles and greater Mexico City was part of a research-action initiative sponsored by the United Nations University (UNU). The broader context of the work included parallel work in four other large urban regions (Mumtai, Manila, Johannesburg, and Tokyo). If the 260 municipalities in the UNU study of six megacities are typical, then urban social vulnerability remains a serious problem as yet INSUFFICIENTLY FACED by municipal, metropolitan, or other higher orders of government.

Among lessons learned is that municipal level assessment of and planning for highly vulnerable social and demographic groups is characterized, despite "best practices" in a small number of municipalities, by: (1) Fragmented and uncoordinated responsibility for different at-risk groups; (2) Legal barriers to access to social data; (3) Staffing shortage and lack of training in use of available social data resulting in little use of existing sources; (4) Limited or ritualistic use of community or neighborhood groups; (5) Limited or sometimes no planning at municipal level for longer term recovery issues; (6) Political hostility toward NGOs; (7) Funding shortages and high turn over in NGO staff.

On the positive side, however, the UNU study also revealed the following: (1) Innovative use of existing neighborhood groups for preparedness or even for hazard and vulnerability mapping. In other words, it CAN be done; (2) Cases of excellent coordination between municipality and NGOs; (3) Improvements in risk communication and increased sensitivity on the part of some municipalities to the needs of foreigners, both legal arid illegal; (4) The exponential growth of CBOs and NGOs during the decades of the 1930s and l990s, therefore producing a basis -- with all the pro's, con's and difficulties mentioned earlier -- for much deeper and systematic relations between cities and civil society.

Title: **Understanding Urban Seismic Risk Around the World**

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Hazard examined: Earthquakes

Study emphasis: Economic development and risk assessment and management strategies.

Summary: Offers a comprehensive assessment of earthquake risk and the state of risk management in each participating city included in the study. Sixty-five city profiles are provided which include a brief physical and historical overview of each city, an outline of previous and existing risk management and mitigation strategies employed at the site and a detailed analysis of the city's earthquake disaster risk.

Vulnerability Indicators: None listed

Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application: Economic Development, Disaster Preparedness

Data Requirements: 31 scalar indicators to assess risk of earthquake disaster; survey questions and case studies of risk management efforts made to reduce city's risk

Output:

- Systematic comparative assessment of the magnitude, causes, and ways to manage earthquake risk in cities worldwide.

- Final report includes:

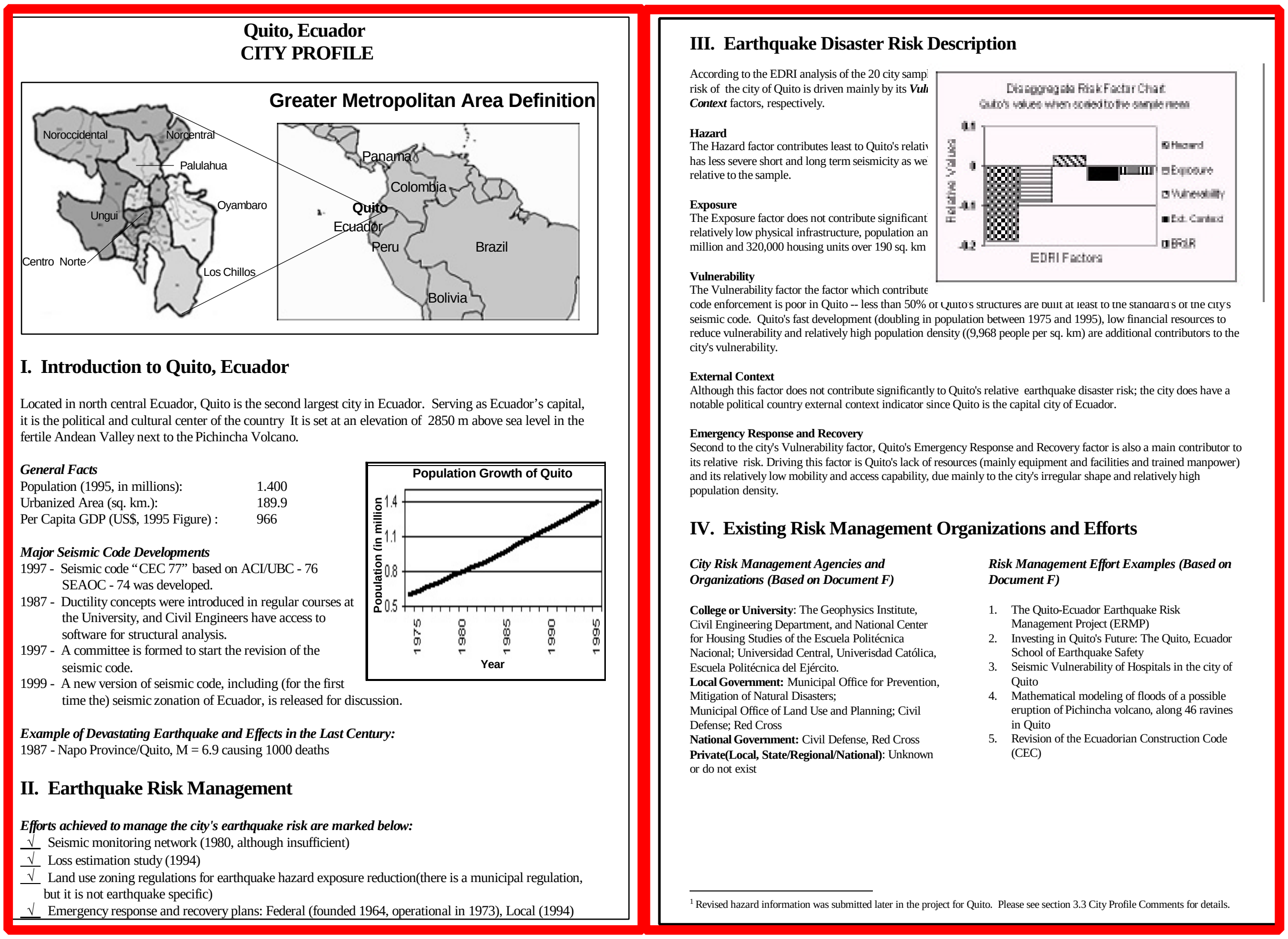
a. Summary comparison of earthquake risk and its contributing factors (Hazard, Exposure, Vulnerability, External Context, Emergency Response & Recovery Capability), and state of risk management in participating cities.
b. For each participating city, a two-page profile of the city's earthquake risk, its causes, and efforts undertaken to reduce it (see attached example).
c. Compilation of 65 case studies describing risk management efforts made in the participating cities using a consistent format (see attached example).

- Worldwide network of earthquake professionals.

Results of Application at Case Study Site: Several efforts have grown out of the study, including the following:

- El Salvador reps. used results to raise awareness of risk in their city. Hosted meeting of local decision makers, in which project results were presented and used as framework for discussion of risk and how to manage it.
- Omar Cardona of Bogota, Colombia and Dora Roitman of San Juan, Argentina are developing similar indexes to compare the regions within their city and province, respectively.
- Following the Izmit, Turkey earthquake in August 1999, GeoHazards International (GHI) used the database of information from the project to help interpret the significance of the event in a press release it made.
- GHI is also continuing to develop and expand application of the earthquake risk index concept by exploring various models, data gathering techniques, and uses.
- GHI and a city representative from India are considering developing a similar index for rural areas.
- I am developing a similar index comparing hurricane risk of counties in the U.S.--ultimately, the indexes could be multi-hazard.

Lessons Learned:
- The internet enabled this truly global project.
- Local participation was important. City representatives were enthusiastic and offered a lot of valuable input.
- Even seemingly simple data are sometimes difficult to obtain in some cities.
- A systematic, comparative assessment of earthquake risk can be useful for raising the awareness of earthquake risk among local officials and the public, and for resource allocation among cities (or similar jurisdictions). The project results can be helpful both in providing the final risk-based rankings and in offering a framework for systematic discussion of the issues associated with earthquake risk and risk management.



Quito, Ecuador
CITY PROFILE

I. Introduction to Quito, Ecuador

Located in north central Ecuador, Quito is the second largest city in Ecuador. Serving as Ecuador's capital, it is the political and cultural center of the country It is set at an elevation of 2850 m above sea level in the fertile Andean Valley next to the Pichincha Volcano.

General Facts

Population (1995, in millions):	1.400
Urbanized Area (sq. km.):	189.9
Per Capita GDP (US$, 1995 Figure) :	966

Major Seismic Code Developments

1997 - Seismic code "CEC 77" based on ACI/UBC - 76 SEAOC - 74 was developed.
1987 - Ductility concepts were introduced in regular courses at the University, and Civil Engineers have access to software for structural analysis.
1997 - A committee is formed to start the revision of the seismic code.
1999 - A new version of seismic code, including (for the first time the) seismic zonation of Ecuador, is released for discussion.

Example of Devastating Earthquake and Effects in the Last Century:
1987 - Napo Province/Quito, M = 6.9 causing 1000 deaths

II. Earthquake Risk Management

Efforts achieved to manage the city's earthquake risk are marked below:

√ Seismic monitoring network (1980, although insufficient)
√ Loss estimation study (1994)
√ Land use zoning regulations for earthquake hazard exposure reduction(there is a municipal regulation, but it is not earthquake specific)
√ Emergency response and recovery plans: Federal (founded 1964, operational in 1973), Local (1994)

III. Earthquake Disaster Risk Description

According to the EDRI analysis of the 20 city sampl risk of the city of Quito is driven mainly by its ***Vul*** ***Context*** factors, respectively.

Hazard
The Hazard factor contributes least to Quito's relativ has less severe short and long term seismicity as we relative to the sample.

Exposure
The Exposure factor does not contribute significant relatively low physical infrastructure, population an million and 320,000 housing units over 190 sq. km

Vulnerability
The Vulnerability factor the factor which contribute code enforcement is poor in Quito -- less than 50% of Quito's structures are built at least to the standard's of the city's seismic code. Quito's fast development (doubling in population between 1975 and 1995), low financial resources to reduce vulnerability and relatively high population density ((9,968 people per sq. km) are additional contributors to the city's vulnerability.

External Context
Although this factor does not contribute significantly to Quito's relative earthquake disaster risk; the city does have a notable political country external context indicator since Quito is the capital city of Ecuador.

Emergency Response and Recovery
Second to the city's Vulnerability factor, Quito's Emergency Response and Recovery factor is also a main contributor to its relative risk. Driving this factor is Quito's lack of resources (mainly equipment and facilities and trained manpower) and its relatively low mobility and access capability, due mainly to the city's irregular shape and relatively high population density.

IV. Existing Risk Management Organizations and Efforts

City Risk Management Agencies and Organizations (Based on Document F)

College or University: The Geophysics Institute, Civil Engineering Department, and National Center for Housing Studies of the Escuela Politécnica Nacional; Universidad Central, Univerisdad Católica, Escuela Politécnica del Ejército.
Local Government: Municipal Office for Prevention, Mitigation of Natural Disasters;
Municipal Office of Land Use and Planning; Civil Defense; Red Cross
National Government: Civil Defense, Red Cross
Private(Local, State/Regional/National): Unknown or do not exist

Risk Management Effort Examples (Based on Document F)

1. The Quito-Ecuador Earthquake Risk Management Project (ERMP)
2. Investing in Quito's Future: The Quito, Ecuador School of Earthquake Safety
3. Seismic Vulnerability of Hospitals in the city of Quito
4. Mathematical modeling of floods of a possible eruption of Pichincha volcano, along 46 ravines in Quito
5. Revision of the Ecuadorian Construction Code (CEC)

[1] Revised hazard information was submitted later in the project for Quito. Please see section 3.3 City Profile Comments for details.

Figure 1. Example of a city profile.

1. Name of Project: Revision of the Ecuadorian Construction Code (ECC)

2. Description: Eight sub-committees have been integrated to revise and update the ECC which accounts for local seismological, geological, soils and materials conditions. Funds are available to develop the first chapter, related to a seismic zonation of the country and the definition of the design spectra.

3. Effort Maker(s): Technicians of six universities in the country.

4. Targeted Recipient(s): Since the purpose is to reduce the seismic vulnerability of new construction, the target groups are the architects, structural engineers, designers, constructors, construction material providers, municipalities in charge of authorizing the constructions.

5. Targeted Need(s): Infrastructure vulnerability

6. Form of Implementation: Start the revision of the code and promote its enforcement

7. Level of Implementation: Countrywide

8. Evaluation of Success: Cannot be established yet, but it could be seen as a success for the fact that it is a multi-disciplinary and inter-institutional effort

9. Contact Information:

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Figure 2. Example of a risk management case study.

VAT II Workshop
Case Studies

Case study title:	**Vulnerability Assessment of a Port and Harbor Community to Earthquake-Tsunami Hazards**

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Case study emphasis: This case study focused on the vulnerability of port and harbors to earthquake and tsunami hazards.

Summary: This two-year research, planning and outreach initiative focuses on building resiliency within Pacific Northwest port and harbor communities to earthquake and tsunami hazards. To achieve this goal, a community-based planning process is being developed, through the use of two demonstration communities, that effectively integrates local stakeholder values, technical expertise, and GIS-based scenario development. Inputs include community workshops, field assessments, and a hazard/vulnerability GIS project. Outputs include community-based Mitigation Action Plans, tailored for specific elements of a port and harbor community. This methodology is appropriate and applicable for small- and moderately-sized coastal communities. For more information, refer to the following publication: Wood, N., Good, J., and Goodwin, B., 2002, Vulnerability assessment of a port and harbor community to earthquake and tsunami hazards: integrating technical expert and stakeholder input, Natural Hazards Review, 3 (4), 148–157.

Date that model application was completed:
The vulnerability assessment for the larger community hazard mitigation planning process was completed on March 1, 2001.

Case study geographical location:
This case study focused on the port and harbor communities in the Pacific Northwest. Two demonstration communities were chosen for the development of the planning process and vulnerability assessment process. They included the port and harbor communities surrounding the Yaquina River, Oregon, and Sinclair Inlet, Washington.

Vulnerability assessment indicators:
Resource vulnerability and community vulnerability, including buildings, infrastructure, populations, response operations, community recovery, local economy, and environmental resources

Methodology data requirements:
- GIS and other data on seismic and tsunami hazards for potential scenarios
- GIS and other data to facilitate vulnerability assessment, e.g., geology, ground shaking potential, soils, elevation, bathymetry, structural footprint, utilities, roads, demographics, historic landslides
- Information to support two community workshops: one focusing on Vulnerability Assessment and the other on Mitigation Options Development

Direct participants in the application of the model of the vulnerability assessment:

County, Local, and State/Provincial Governments
Non Governmental Organization
Private Volunteer Organization
Research/Training Institute
Civic Association
Private Consulting Firm

Economic and social sector participants directly involved:
Workshop participants included representatives from American Red Cross, residents, resort managers, retail store owners, port officials, an assisted living facility director, boat owners and commercial fishing officials, Chamber of Commerce and officials from city, county, state and federal agencies and departments.

Methodology objective:
This project focuses on building the resiliency of Pacific Northwest port and harbor communities to earthquake and tsunami hazards. To achieve this goal, a community-based planning process is being developed and tested in two communities. The process is designed to integrate local stakeholder values, technical expertise, and GIS-based scenario development. One component of this planning process is a community-based vulnerability assessment.

Methodology output:
- Community partnerships – a partnership network of port and harbor users, agencies, and businesses is created
- GIS-based exposure maps – numerous maps were created that showed which resources were exposed to the various hazards
- Prioritized vulnerability issues – stakeholders prioritize the numerous vulnerability issues, with regards to their impact on the entire port and harbor community

Results of methodology application at case study site:
Results of the community vulnerability assessments are prioritized at later mitigation workshops. From these discussions, a series of sector-specific mitigation action plans are created. These sectors include a) emergency services, b) lifelines, c) waterfront industries, d) tourism, lodging, retail businesses and residences, and e) community planning and the environment

Lessons learned:
- Building stakeholder partnerships early in the project is critical for project success
- Inclusion of stakeholder input has allowed assessments to elevate from resource exposure to community vulnerability
- Elevation from resource vulnerability to community vulnerability is an important step for prioritizing community mitigation actions
- Assessments from both geographic and functional (i.e., sector-specific) viewpoints provide more robust representation of community issues

Title: **Coastal Vulnerability Assessment in Barbados**

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Hazards Examined: Multi-hazard

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: The Caribbean Planning for Adaptation to Global Climate Change project (CPACC) is assisting Caribbean Countries in preparation to cope with adverse effects of global climate change (GCC). A priority concern is sea level rise in coastal and marine areas, for which vulnerability assessment, adaptation planning and capacity building linked to adaptation planning will be undertaken. Barbados, Grenada, and Guyana have agreed to participate in the development and use of vulnerability and risk assessment models for their coastal areas.

The Case Study will be looking at Barbados' development of vulnerability and risk assessment. The areas covered will be the direct impacts of relative sea level rise on the coastline of Barbados 9with particular attention to the south and west coasts as they are the most heavily populated and sites the island's most critical infrastructure, and the impacts of the associated effects of sea level rise (i.e. erosion, inundation and salinization) on the coastline of Barbados.

Vulnerability Indicators:
Data Requirements:
Output:
Results of Application at Case Study Site:
Lessons Learned:
URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

Title:	**GIS-based Hazard Vulnerability Assessment of Critical Facilities, Antigua and Barbuda**	

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Hazards Examined: Multi-hazard

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: A vulnerability assessment of critical facilities in Antigua and Barbuda to natural hazards was conducted in order to inform the country's national hazard mitigation plan. Regional-scale maps of individual hazards were combined with a critical facilities database containing spatial and attribute data on various structures to determine the locational vulnerability of each facility. A facility vulnerability score was then calculated for each facility based on its locational vulnerability, and the weighted assessment of each facility in terms of damage history, structural vulnerability and operational vulnerability for each hazard. The procedure generates maps and tables of relative facility vulnerability associated with individual hazards and/or multi-hazards.

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

Title: **Application of a Statewide Multi-Hazard Vulnerability Assessment Model to Rhode Island**

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Hazards Examined: Multi-hazard

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: A methodology was developed in conjunction with the NOAA Coastal Services Center to perform regional vulnerability assessments for use in statewide planning in the U.S. The methodology is a simplified approach to modeling using publicly available data and GIS tools, and is intended to aid in allocating resources to state mitigation programs. The methodology is applied to the state of Rhode Island, which is preparing a state mitigation plan for numerous hazards and exposures.

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

Title:	**Rural Roads Vulnerability Reduction Assessment, Mitigation Measures, and Training**

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Hazards Examined: Multi-hazard

Study emphasis: Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: This study involves an assessment, through community involvement, surveys and subsequent reviews of given rural road conditions, and the development of roads 'worklists' that are aimed at defining needed improvements and "disaster proofing" roads and roadway systems. Outputs have included identification of specific needed road work with use of the worklist and drawings, and conducting training on basic design, construction, and repair measures applicable to minimizing vulnerability of the roads and reducing environmental damage. (See attached summary write-up)

Vulnerability Indicators:

-Roads located in vulnerable areas (on landslides, in floodplains, on steep slopes, etc).
-Frequent need for road maintenance.
-Damage or needed repairs from small storm events.
-Undersized drainage structures.
-Critical transportation links between communities or areas.

Data Requirements:

-Road inventories.
-Hazard risk maps, if available.
-Qualitative field assessment of road conditions.

Output:

-An inventory of needed road work, by priority.
-Work lists developed for needed work (See Attached Work List forms)

-Documentation of measures and conducting training on measures useful to reduce road damage from disasters.

Results of Application at Case Study Site:

-Implementing road improvements to make roads more "storm resistant".
-Less frequent and less severe damage to roads (less plugged pipes and washouts, etc), less costly repairs, and less road closures.

Lessons Learned: See attached list of measures for reducing vulnerability of rural roads to natural disasters.

URL(s) or bibliographical references to/for publications about your case study:
Key references on this specific issue:

PIARC World Roads Association. 1999. Natural Disaster Reduction for Roads, Final Report 72.02B, Paris, FR. 275p.

Copeland, R.; Johansen, K. 1998. Water Roads Interaction: Examples from Three Flood Assessment Sites in Western Oregon. Report 9877-1805-SDTDC, San Dimas, CA. Technology and Development Center, U.S. Department of Agriculture, Forest Service. 15p.

De La Fuente, J. 1998. The Flood of 1997, Klamath National Forest. Unpublished Report, Yreka, CA. U.S. Department of Agriculture, Forest Service.

Rural Road Vulnerability Reduction Assessment, Mitigation Measures, and Training

By

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Summary

The US Forest Service has gained considerable experience in storm damage assessment and repair work over the past 30 years. Major storm damage repair programs have been undertaken in the western United States after the storm events of 1972, 1986, 1995, and 1997. Also considerable experience has been gained with road work throughout Central America after Hurricane Mitch and in the Caribbean after Hurricane Georges.

ASSESSMENT

Two levels of assessment have been used for road storm damage projects, depending on the scope of needed work and geographic extent of damage.

1. Program Prioritization of Roads (Large Area Assessment)
2. Project Road Work and Identified Mitigation Measures (Specific Existing Roads)

Program Priorities

Program Priorities are influenced by both Social and Physical considerations. Project selection has been based upon a subjective consideration of all priorities and factors, and the need to develop a balanced program of work.

Remember--**Long-term Programs Need Short-term Successes!**

Social Considerations

- Community Needs and Desires
- Community Involvement and Sustainability
- NGO support

Physical Considerations

- Watershed Priorities
- Road Use and Importance
- Feasibility of Desired Repairs
- Cost-Effectiveness

Project WorkPriorities

Project Work Priorities have typically been based upon road use and standard of the road. The most heavily used arterial and collector roads usually receive top priority and are repaired first and best. Secondary, local roads typically receive a lower priority. Road managers must have an inventory of or know their transportation system!

MITIGATION MEASURES

For any specific existing road or road system, a variety of planning and design tools are available to rural roads managers and engineers to help "storm-proof" a road and reduce the vulnerability of roads to natural disasters. A list of specific recommendations, or "Best Practices", is presented on the following pages (attached).

The work needed can be identified in the field on a work list, where the specific item, site conditions, and description of work, are listed by station or milepost along the road. See the attached Work List form and an example of a specific work list developed for a road project in Honduras after Hurricane Mitch. Most identified items of work involve improving roadway surface drainage to avoid water concentration and having well designed drainage crossings. Other common items of work include subgrade stabilization, slope treatments or needed retaining structures, and erosion control measures.

TRAINING

Over the past eight years considerable training has been conducted throughout Latin America on "Minimum Impact Rural Roads" and on the application of "Best Management Practices" to low-volume roads. The objectives of this training have been:

1. To improve basic road planning, design and construction, and repair techniques;
2. To discuss Environmental Analysis and reduce adverse environmental impacts from roads; and
3. To reduce the vulnerability of roads to natural disasters, particularly from storm events and flooding.

Work List Form

Road/Area____________

Station Or MP	Road Width m	Road Grade %	Cross-Slope %	Code	Work Description

Work List (Sample)

Road/Area--Desvio Sabana Hoyosa (Road P1T4)

Location, Station or MP	Road Width m	Road Grade %	Cross-Slope %	Code	Work Description
D1 (MP 0.0)					Intersection with P1 at Saddle
	4+1RL	0-18			Inslope Road to Ditch, Clean Ditch
D2					Install 24" Pipe & Drop Inlet, Drain Left
		11-12			Outslope Road, Reshape Rough Road Surface
D3 (MP 0.1)					Construct Dip, Drain Left
		3			Outslope Road
D4					Clean Existing Timber Culvert
		3			Inslope Road to Ditch
D5					Excavate Inlet Basin for Timber Culvert
	3.5+1RL	+3--3			Inslope Road and Reshape Ditch
D6					Replace Damaged Timber Culvert with an Armored Dip
		+3--3			Reshape Road and Ditch
D7					Construct Dip, Drain Left
		3 -5			Inslope Road, Reshape Ditch
D8 (MP 0.35)					Existing Timber Bridge Marginal—Eventually Replace with an Armored Ford
		7			Inslope Road, Reshape Ditch
D9					Replace Plugged Existing Timber Culvert With Culvert or Dip (Lower Grade 45 cm)
		2-10			Outslope Road and Construct 3 Dips, Drain Left
D10					Construct Dip, Drain Right
		10-16			Smooth Existing Roadway Alternative-Relocate Road between D10 & D11
D11					Construct Dip Left
		6			Outslope Road
D12 (MP 0.7)					At Gentle Saddle—Road OK
		2-5			Outslope Road, Construct 6 Dips between D12 & D13
D13 (MP 1.1)					Begin Ridgetop Road, Road OK

Measures for Reducing Vulnerability of Rural Roads to Natural Disasters

- Identify areas of historic or potential vulnerability, such as geologically unstable materials or areas, areas subject to flooding, or areas of high volcanic or seismic hazards.

- Avoid problematic areas and avoid road locations in areas of high natural hazard risk, such as landslides, rock-fall areas, steep slopes (over 60-70%), wet areas, saturated soils, etc.

- Avoid or minimize construction in narrow canyon bottoms or on flood plains of rivers that will inevitably be inundated during major storm events.

- Provide good roadway surface drainage and rolling road grades so that water is dispersed off the road frequently and water concentration is minimized.

- Minimize changes to natural drainage patterns and crossings to drainages. Drainage crossings are expensive and potentially problematic, so they must be well designed. Changes to natural drainage patterns or channels often result in either environmental damage or failures.

- Out slope roads whenever practical and use dip cross-drains for surface drainage rather than a system of ditches and culverts which require more maintenance and can easily plug during major storm events.

- Use simple fords or vented low-water crossings (vented fords) for small or low-flow stream crossings instead of culvert pipes that are more susceptible to plugging and failure. With fords, protect the entire wetted perimeter of the structure, protect the downstream edge of the structure against scour, and provide for fish passage where needed.

- Perform scheduled maintenance to be prepared for storms. Insure that culverts have their maximum capacity, that ditches are cleaned, and that channels are free of debris and brush than can plug structures. Keep the roadway surface shaped to disperse water rapidly and avoid areas of water concentration.

- Typically keep cut and fill slopes as flat as possible and well covered (stabilized) with vegetation to minimize slumping as well as minimize surface erosion. Well-cemented but highly erosive soils may best resist surface erosion with near-vertical slopes that minimize the surface area exposed to erosion.

- Use deep-rooted vegetation for biotechnical stabilization on slopes. Use a mixture of good ground cover plus deep-rooted vegetative species, preferably native species, to minimize deep-seated mass instability as well as offer surface erosion control protection.

- Locate bridges and other hydraulic structures on narrow sections of rivers and in areas of bedrock where possible. Avoid fine, deep alluvial deposits (of fine sand and silt) that are scour susceptible and problematic, or which otherwise require costly foundations.

- Design critical bridges and culverts with armored overflow areas near the structure to withstand overtopping, or have a controlled "failure" point that is easy to repair. Alternatively over-sizing the structure and allow for extra freeboard on bridges to maximize capacity and minimize risk of plugging. Also avoid constricting the natural channel.

- Insure that structural designs for bridges, retaining walls, and other structures include appropriate seismic design criteria and have good foundations to prevent failures during earthquakes.

- Place retaining structures, foundations, and slope stabilization measures into bedrock or firm, in-place material with good bearing capacity to minimize undermining, rather than placing these structures on shallow colluvial soil or on loose fill material.

Title:	**Hazard Vulnerability and Consequence Analysis: Building Sustainable Communities**

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Hazards Examined: Multi-hazard

Study emphasis: Vulnerability Analysis, Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: An assessment of the impact of a hazard on a community provides information on the immediate consequences of a hazard event. The capacity of a community to recover from a disaster is a reflection of social, economic, and environmental indicators. Communities with high unemployment, environmental contamination, and social problems are at a significant disadvantage to respond and recover from a disaster. Communities with a stable transportation, utility, and communication infrastructure are in a far better position to cope with disaster. Effective disaster response is based on strong educational, health, political, and social systems. Communities that are experiencing economic crisis, social disorder, and political unrest may find it difficult if not impossible to cope with disaster. An understanding of the nature and characteristics of hazards and disasters is essential to the short and long term sustainability of a community.

Vulnerability Indicators: Unemployment Rate, Crime Rate, Pre-mature Birth Rate, School Drop-out Rate, Average Income, Recreation to Population Ratio, and Autos to Population Ratio

Data Requirements: Employment, Census Bureau, education, parks and recreation, health care, and economic data.

Output: Community Profiles reflecting social, economic, and environmental indicators.

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

http://www.risk.lsu.edu

For more information on this case study, please contact the author.

Title: **Sustainable Development Planning for Eight Puerto Rico Municipalities**

Contact(s):
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Hazards Examined: Multi-Hazard

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: This study involved the development of an integrated hazard assessment methodology that used a GIS-driven constraint analysis to evaluate multiple hazards. It employs a "vulnerability index" that relates the intensity of past damages to the reoccurrence interval for each hazard, then compares different hazards to create a composite hazard map. The integrated hazard assessment was then tied to a more traditional land suitability analysis to identify future growth areas, sensitive development areas where Best Management Practices (BMPs) should be implemented, and high hazard areas where intense development should be discouraged.

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

Title:	**Methodology for Evaluating and Prioritizing Projects Related to Flood Mitigation Planning**	
Contact(s):	Name:	Peter Throop
	Agency:	City of Keene Planning Department and Antioch New England Graduate School
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Hazards Examined:	Flooding	
Study emphasis:	**Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application	
Summary:	This case study will cover the process used by the City of Keene, NH to identify properties and structures found to be vulnerable to flood damage. The approach classifies these properties into Critical Facility, Residential, and Commercial and Industrial categories, and then analyzes available information to assess the nature of the risk from a systems perspective.	

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

Title: **A Web-Based Coastal Risk Atlas for Performing Community Vulnerability Assessments**

Contact(s):
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Agency: NOAA National Coastal Data Development Center (NCDDC) and Neptune Sciences Inc.
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Hazards Examined: Hurricanes and tropical storms (and related hazards)

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: NOAA's NCDDC is developing and implementing Web-based technologies for local users to identify and access data and information to apply the Community Vulnerability Assessment Tool (CVAT) developed by the NOAA Coastal Services Center (CSC). During the present phase planned for completion this fall, the technologies are being demonstrated with sample data and products for two pilot areas; the Mississippi coast and the east coast of Florida near the St. Johns River. The effort covers hazards and vulnerabilities associated with coastal storms, primarily tropical storms and hurricanes for the pilot areas. By utilizing the Internet, this approach will facilitate performing community vulnerability assessments better, more efficiently, and in a greater number of locations.

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

Title: **Integrated Hazard Assessment for the Island of Puerto Rico**

Contact(s):

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Hazards Examined: Multi-hazard

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: This study presents an integrated assessment of natural hazards for the island of Puerto Rico. Economic loss potential will be the basis for integrating disparate hazard events. Primary users of this information include local and regional land-use planners.

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

Title:	**Creation of a Social Vulnerability Index**	
Contact(s):	Name:	Susan L. Cutter
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	Fax:	803-777-4972
	E-mail:	scutter@sc.edu
Hazards Examined:	Multi-Hazard	
Study emphasis:	Please select all that apply: Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application	
Summary:	A methodology is presented for differentiating U.S. counties according to their level of social vulnerability. A series of specific indicators were produced and then mapped to highlight differences between and among counties. A specific subset of counties (Gulf and Atlantic Coast) was used to test the methodology's application on a regional basis. The transferability of the methods to other countries or regions is assured as it is based on the demographic, economic, and housing characteristics of the place and more importantly, uses standardized data sources such as the US Census.	

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

1. Georgetown Case Study
2. American Hazardscapes

For more information on this case study, please contact the author.

Title:	**Evolution of Earthquake and Hurricane Risk Ranking in the United States**	

Contact(s):

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Hazards Examined: Multi-hazard

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: This study will review the evolution of natural hazards risk ranking methodologies as used by FEMA for the allocation of state assistance funds. It will examine the sensitivity of risk rankings to the evolution of hazards data and changes in focus from populations to the built environment.

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

Title:	**Vulnerability to Natural Hazards of School Buildings Used as Emergency Shelters**

Contact(s):

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Hazards examined: Earthquakes, floods, and hurricanes.

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: A methodology for the qualitative assessment of school buildings with respect to their vulnerabilities to hurricanes, earthquakes, and torrential rainfall will be presented. The shortcomings of the methods will be outlined. The methodologies include field investigations, reviews of a limited number of available documents, interviews, and desk exercises.

Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

Title: **Hurricane Loss Estimates in Real-Time for the Caribbean Islands**

Contact(s):

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Hazards Examined: Multi-hazard

Study emphasis: **Please select all that apply:** Economic Development, Disaster Preparedness, Disaster Response and/or Disaster Reconstruction Application

Summary: AIR is the leading provider of catastrophe modeling technology. AIR has been providing reliable real-time loss estimates to insurance industry since 1989 for major worldwide natural catastrophes. This presentation will focus on one such hurricane event that affected the Caribbean region. The AIR methodology will be described in this case study for which either Hurricane Floyd or Georges will be selected

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Vulnerability Indicators:

Data Requirements:

Output:

Results of Application at Case Study Site:

Lessons Learned:

URL(s) or bibliographical references to/for publications about your case study:

For more information on this case study, please contact the author.

VAT III Workshop
Case Studies

Case study title:	**Integrating Vulnerability Assessments with Development Planning Efforts in the Caribbean**

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Case study emphasis: Integrated hazard assessment, mitigation planning, sustainable development planning

Summary:

Offers a GIS-driven risk-based methodology that enables communities and island nations in the Caribbean to develop land use plans built upon a foundation of disaster resilience and sustainable development. The damage potential (expressed in terms of economic loss to a typical housing type) was quantified for each hazard for a consistent return period (100 years). A composite hazard map was prepared that integrates the damage potential for each hazard simultaneously to show the intensity or levels of composite hazard throughout the island. This methodology allows a consistent framework to: delineate areas at risk and define possible consequences; target development in areas less susceptible to natural hazards; provide a basis to support planning decisions that will reduce the impact of natural hazards on people and property; and, provide a framework for conducting vulnerability assessments.

A land use suitability analysis was linked to the risk assessment to identify future growth areas, areas where new development should be discouraged, and areas where specific engineering design or Best Management Practices (BMPs) should be implemented. The hazard assessment methodology was designed to evaluate individual and composite natural hazards throughout the island, in addition to allowing the 78 municipalities in Puerto Rico to download hazard information for their own community. The study included a capability assessment that evaluated existing laws, regulations and policies related to land development and the ability of Puerto Rico agencies to implement a range of hazard mitigation actions. A mitigation planning guide for local jurisdictions was prepared to facilitate the development of community-level hazard mitigation plans. A website was created to enable State agencies and local jurisdictions to have access to hazard maps and guidance documents that could be understood by a non-technical audience.

This study effort will provide the framework for Puerto Rico's Commonwealth Hazard Mitigation Plan.

The Integrated Hazard Assessment has become an important tool for administrative and regulatory agencies in Puerto Rico. It:

- Strengthens state-level hazard mitigation planning and creates a strong mechanism to encourage local-level hazard mitigation planning;
- Provides information useful for the development of a comprehensive mitigation strategy;
- Enhances planning and development decisions in rural municipalities by providing information to introduce natural risk reduction measures into community long-range development programs or plans;
- Provides a valuable tool to Central Government agencies to facilitate sound decision-making when reviewing major development projects throughout the Island;
- Develops a hazard information database that provides the foundation for a state-wide risk and vulnerability assessment.

Date that model application was completed: April 2002

Case study geographical location: Puerto Rico

Vulnerability assessment indicators:
Hurricane-strength winds, storm surge, flood, rainfall-induced landslides, seismic hazard indicators including ground shaking and liquefaction; and associated damage functions for specified land uses and reoccurrence intervals.

Methodology data requirements:
individual hazard profiles, intensity/frequency relationships, susceptibility maps that differentiates variations in hazard intensity due to local conditions, damage functions for each hazard, damage potential (expressed in terms of potential property loss) related to each hazard (expressed as a percentage of building replacement value),GIS application to cumulatively combine the damage potential for the individual hazards to develop a composite hazard ranking.

Direct participants in the application of the model of the vulnerability assessment:
Local and National Governments

Economic and social sector participants directly involved:
Community Associations, key industrial/commercial stakeholders in the community.

Methodology objective:
To create a composite hazard assessment for the Island of Puerto Rico that encourages local hazard mitigation planning and promotes sustainable development planning.

Methodology output:
Individual hazard maps and composite hazard map for the Island of Puerto Rico and its 78 municipalities; hazard mitigation plans; integrating hazard mitigation elements into comprehensive land use plans.

Results of methodology application at case study site:
The Integrated Hazard Assessment for Puerto Rico will provide the framework for the development of a Commonwealth Hazard Mitigation Plan and associated municipal-level hazard mitigation plans that are compliant with the U.S. Federal Emergency Management Agency (FEMA) recently enacted Disaster Mitigation Act of 2000.

Lessons learned:
Difficulties inherent in applying consistent vulnerability assessment tools for large urban areas, medium-sized cities, and low-density, rural communities with limited capabilities. Need for simplified loss estimation tools for addressing critical infrastructure, lifelines, and other important public and private sector facilities located in hazard-prone areas. Trade-offs between the use of annualized damages (standard approach for benefit/cost analyhsis) and the use of single point estimates (using a uniform re-occurrence interval that would apply to disparate natural hazards). Application of several GIS-driven hazard assessment and vulnerability assessment methodologies and their value (and associated costs) in developing comprehensive land-use plans that are built around the framework of disaster resilience and sustainable development planning concepts.

Case study title: **Hurricane Mitigation Study for GSA**

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Case study emphasis: building risk rating and mitigation measures and costs

Summary:

GSA was required by Congress to develop an inventory of federally-owned buildings that could be impacted by hurricanes, to rank those buildings into risk categories, and to develop possible mitigation measures for those buildings to reduce the financial impact to GSA from hurricane events. GSA needed the study complete for the 121 buildings located in six southeastern states within 4 months and at minimal study cost.

URS developed a methodology that utilized existing data about the buildings; this method required verification by actually visiting only 4 buildings. The existing data included GSA developed information on building structure type, number of floors, age, amount of glazing, etc. URS developed a series of site-specific GIS maps showing the building's relative location with respect to the floodplain, storm surge inundation, and wind isotachs. The building information and the hazard information were then used to develop a risk rating for each building.

Each building was rated as very high risk, high risk, medium risk, and low risk. Based on building construction type, age, roof construction, windows (and other building characteristics) and location relative to the hazards, conclusions can be drawn about the likely performance of the building during a hurricane event. A risk grading scale was created that accounted for the most important factors in building design and each building was "scored" and placed in one of the four risk categories.

The expected building performance, the building construction type and other characteristics also suggested a range of possible mitigation measures, each with an associated unit cost. From the grading scale and the presence of or lack of certain characteristics, and the building size, a cost estimate of the mitigation measures was developed.

For summary and presentation purposes, using spreadsheet and database tools, total estimates for the buildings located in each state in each risk category were created. It is expected that the use of the rapid risk rating method and the cost estimates developed from this rating will help improve the delivery of a shorter list of buildings that actually need to be retrofitted with appropriate mitigation improvements. One of the benefits of assessment methods such as this, is that a large number of buildings can be evaluated with minimal field visits, at minimal cost, in minimal time yet the result provides the user with a set of buildings that have been screened with an action plan for taking the next steps.

Date that model application was completed: September 16, 2002

Case study geographical location: Southeast United States

Vulnerability assessment indicators: Building location with respect to floodplain, storm surge and wind isotachs, building age and construction type, natural hazard history at the site

Methodology data requirements: building location information, building structure type, age, amount of glazing, roof type, openings in building below expected flood, natural hazard history

Direct participants in the application of the model of the vulnerability assessment:
National and Subnational (regional) Governments
Private Consulting Firm

Economic and social sector participants directly involved:

Methodology objective: determine likely risk each building has to damage from hurricanes, rank buildings as very high risk, high risk, medium risk, and low risk

Methodology output: ranking of buildings per requirements with a mitigation cost for each building, cost for each risk category and for each state.

Results of methodology application at case study site: development of mitigation costs for each risk category for each state

Lessons learned: application of existing data on buildings and hazards can be used with a minimum amount of actual on-site information – method could save many dollars in the building screening process.

Case study title:	**Montserrat Integrated Vulnerability Analysis**

Contact(s)

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Case study emphasis: Vulnerability reduction

Summary:

Since the Soufriere Hills volcano began erupting in 1995, Montserrat has undergone substantial physical, economic, social and institutional changes. The destruction and evacuation of the capital city, Plymouth, in 1997 prompted the migration of more than 5,000 people and necessitated the relocation of the remaining population to the northern one-third of the island.
In an attempt to recover from this disaster, the Government of Montserrat (GoM) has been working ardently towards the redevelopment of the northern section (Safe Zone) of the island. In order to ensure the long-term sustainability of the society and economy, the GoM is giving high priority to disaster mitigation in the design and development of the physical and social infrastructure within the Safe Zone.

In 2002, the GoM contracted Smith Warner International (SWI) for the *Provision of Consultancy Services for an Integrated Vulnerability Analysis of Montserrat*.

The overall goals of this project are to provide a disaster prevention and mitigation framework within which the GoM may develop hazard risk and vulnerability strategies. The main objectives of *The Integrated Vulnerability Analysis of Montserrat* are:

- To present the history of natural and technological hazards in Montserrat.
- To determine the vulnerability of the Safe Zone, and in particular, the proposed development areas to natural hazards.
- To determine the areas in the Safe Zone that are prone to multiple hazards.
- To consider the physical and social infrastructure that are required to meet the island's needs as they exist at this time, as well as those ensuing from the planned development.

- To make disaster mitigation recommendations for development planning and disaster management.

This was done by carrying out the following tasks:

1. Preliminary data gathering and reconnaissance field visit
2. Baseline study and evaluation of development plans
3. Hazard Mapping including
   Wind;
   Storm surge;
   Inland flooding;
   Tsunami;
   Seismic;
   Volcanic; and
   Landslide hazards.
4. Socio-economic Analysis
5. Develop Mitigation Guidelines.

Date that model application was completed: Project Ongoing

Case study geographical location: Caribbean

Vulnerability assessment indicators: Potential for damage from volcanic eruption, storm surge, river flooding, landslides, hurricane winds, tsunami.

Methodology data requirements:
Detailed topographic maps, detailed bathymetric charts, historical storm data, wind data, rainfall data, hydrological data, seismic data, geomorphological data, volcanic data, data on man-made hazards (oil spill, traffic, etc.)

Direct participants in the application of the model of the vulnerability assessment:
National Government
Multilateral Development Agency

Economic and social sector participants directly involved: Government of Montserrat

Methodology objective: To define areas of the Safe Zone that will be the least susceptible to volcanic and other natural hazards.

Methodology output: Primarily hazard maps

Results of methodology application at case study site: Specification of mitigation practices to reduce risk and vulnerability including ranking of proposed development sites.

Lessons learned: Integrated assessment planning should be an essential tool in reducing the vulnerability of communities in the Caribbean.

Case study title:	**National Assessment of Coastal Vulnerability to Sea-Level Rise**

Contact(s):

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Case study emphasis: Development of a technique that maps the relative vulnerability of a region to sea-level rise, useful for developed and undeveloped coastlines, with examples from the United States.

Summary:

A coastal vulnerability index (CVI) was used to map the relative vulnerability of the coastal U.S. to sea-level rise. The CVI ranks the following in terms of their physical contribution to sea-level rise-related coastal change: geomorphology, regional coastal slope, rate of relative sea-level rise, shoreline erosion and accretion rates, mean tidal range and mean wave height. The rankings for each variable were combined and an index value calculated for 3-minute grid cells along the U.S. shoreline. The CVI highlights those regions where the effects of sea-level rise might be the greatest, i.e. where there is the greatest chance that physical changes will occur as sea-level rises. This approach combines the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, yielding a relative and quantitative measure of the system's natural vulnerability to the effects of sea-level rise using objective criteria. Future work will incorporate additional variables such as relative coastal sediment supply, episodic events (hurricane intensity, track, and landfall location, Nor'easter intensity data, and El Nino-related climate data such as short-term sea-level rise) and human influences (e.g., coastal engineering) into the CVI.

Nationally, 30 percent of the U.S. coastline is at very high risk from the effects of rising sea-level. Forty-seven percent of the coast falls into the moderate to high risk range, while twenty-three percent is at low risk. Low-lying barrier islands with a low regional coastal slope characterize those areas of the Atlantic and Gulf of Mexico coasts that are designated as very highly vulnerable. Along the Pacific coast, the most vulnerable locations are pocket beaches lying between rocky headlands, as well as long stretches of low-lying beach. Low risk areas along the U.S. shoreline are typically found in high-relief, rocky coastal settings.

The CVI provides insight into the relative potential of the coastal system to change as sea-level rises in the future. The resultant index data can be viewed in a number of ways: 1) as an example of the potential for using objective criteria to assess coastal vulnerability; 2) as a base for developing a more complete inventory of variables influencing coastal vulnerability; and 3) as a base for developing plans for future investigations related to coastal processes and climate variability.

Date that model application was completed: June, 2001

Case study geographical location: U.S. Atlantic, Pacific, and Gulf of Mexico Coasts

Vulnerability assessment indicators:
We use 6 indicators in calculating the Coastal Vulnerability Index (CVI) – Shoreline Change, Geomorphology, Tide Range, Wave Height, Regional Coastal Slope and Relative Sea-Level Rise.

Methodology data requirements:
The data required for this study are 1) geomorphology, 2) coastal slope (percent), 3) rate of relative sea-level rise (mm/yr), 4) shoreline erosion and accretion rates (m/yr), 5) mean tidal range (m) and 6) mean wave height (m). On the National scale these data were mapped at 3 minute resolution, thus data at this resolution or finer is preferred. Our data sets come from State and Federal agencies, such as NGDC, NOS, the U.S. Army Corps of Engineers, NOAA and the USGS. All of the data assimilation and mapping is done using ESRI products, namely ArcView 3.2. Microsoft Excel is used for the data rankings and the CVI calculation.

Direct participants in the application of the model of the vulnerability assessment:
National Government

Economic and social sector participants directly involved: United States Geological Survey

Methodology objective:
The CVI is intended to be a simple, objective means of evaluation the potential effects of SLR on coastal areas. The CVI ranks the following in terms of their physical contribution to sea-level rise-related coastal change: geomorphology, regional coastal slope, rate of relative sea-level rise, shoreline erosion and accretion rates, mean tidal range and mean wave height. The rankings for each variable were combined and an index value calculated for 3-minute (~3.90 km) grid cells along the U.S. shoreline. The CVI highlights those regions where the effects of sea-level rise might be the greatest, i.e. where there is the greatest chance that physical changes will occur as sea-level rises. This approach combines the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, yielding a relative and quantitative measure of the system's natural vulnerability to the effects of sea-level rise using objective criteria. Future work will incorporate additional variables such as relative coastal sediment supply, episodic events (hurricane intensity, track, and landfall location, Nor'easter intensity data, and El Nino-related climate data such as short-term sea-level rise) and human influences

(e.g., coastal engineering) into the CVI. This method is easily adapted to different data types and resolutions, making it appropriate for use in the Americas.

Methodology output:
This method of assessment results in a table of data, each row of which corresponds to a portion of the U.S. shoreline. The data populating the table are each of the above 6 variables, their rankings and the CVI value. The data area presented as a color coded shoreline that designates each section of the shoreline as low risk, moderate risk, high risk, or very high risk due to the future effects of sea-level rise. The data products include U.S. Geological Survey Open-File reports with maps and interpretations, as well as a U.S. Geological Survey Digital Data Series CD-ROM with all of the data sets for the U.S. Atlantic, Pacific and Gulf of Mexico Coasts.

Results of methodology application at case study site:
Nationally, 30 percent of the U.S. coastline is at very high risk from the effects of rising sea-level. Forty-seven percent of the coast falls into the moderate to high risk range, while twenty-three percent is at low risk. Low-lying barrier islands with a low regional coastal slope characterize those areas of the Atlantic and Gulf of Mexico coasts that are designated as very highly vulnerable. Along the Pacific coast, the most vulnerable locations are pocket beaches lying between rocky headlands, as well as long stretches of low-lying beach. Low risk areas along the U.S. shoreline are typically found in high-relief, rocky coastal settings.

The CVI provides insight into the relative potential of the coastal system to change as sea-level rises in the future. The resultant index data can be viewed in a number of ways: 1) as an example of the potential for using objective criteria to assess coastal vulnerability; 2) as a base for developing a more complete inventory of variables influencing coastal vulnerability; and 3) as a base for developing plans for future investigations related to coastal processes and climate variability.

Lessons learned:
The Coastal Vulnerability Index has been shown to be a simple, yet objective evaluation tool to characterize the risk associated with rising sea-levels. This method is easily adapted to different data types and resolutions, making it appropriate for use in the Americas. Similar hazard mapping for earthquake and volcano risk has been done for the US for a number of years. In an age of rising sea-levels, the CVI has become a necessary and timely tool. Feedback from academic and government scientists has validated the need for the CVI. The National Park Service has requested similar studies in it's coastal parks and is incorporating the results into their 30-year General Management Plans.

Vulnerability assessment indicators:

Methodology data requirements: Observation, questionnaire, PLA techniques and informal discussions

Direct participants in the application of the model of the vulnerability assessment:

Local and National Governments
Multilateral Development Agency
Private Volunteer Organization

Methodology objective: Social assessment of residents' experience as a consequence of hurricane Michele and recent flood rains

Methodology output: Participatory outputs and survey data (verbal and visual)

Results of methodology application at case study site: A report submitted to local and regional funding bodies for implementation of recommendations

Lessons learned: There is need for an inclusionary approach (residents, national, social and physical planners) to the determination and implementation of policy in the areas of both disaster preparedness and disaster mitigation.

- Managing social suffering is a large part of disaster mitigation as vulnerabilities are both personal and national.

- Participatory approaches to information gathering are invaluable as we strive to understand the suffering experienced in natural disasters.

- Peoples' natural wisdom must be taken into consideration in disaster preparedness planning.

- Reconstruction of damaged areas needs to be scientifically and swiftly pursued after a disaster.

Case study title: **A Real Time Application of the TAOS Model - Hurricane Luis 1995**

Contact(s):

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Case study emphasis: The prediction of storm surge and wave heights to determine vulnerable areas during the passage of hurricane Luis over Antigua and Barbuda

Summary: The Arbiter of Storms (TAOS) is a hazard model, developed with the support of USAID/OAS Caribbean Disaster Mitigation Project (CDMP), for assessing the impact of storm surge and wave action on coastal areas throughout the region. It was intended to assist emergency managers, land use planners and meteorologists in assessing the risks associated with these meteorological hazards. A straightforward application of the TAOS model is to estimate, in real time, the effects of an individual active storm.

One such application occurred as hurricane Luis approached the Eastern Caribbean in 1995. The TAOS model was used in real time to compute the storm surges and the wave heights associated with the passage of the hurricane. The input for the model was the current and predicted characteristics of the hurricane, including the location, maximum wind speeds, minimum sea-level pressure and the radius of maximum wind speeds. The source of the information was the advisories and forecasts of the Tropical Prediction Centre in Miami, Florida.

The output from the model run included the maximum storm surge and wave heights, and time series of the surge and wave heights at selected locations. This information was relayed to the Antigua and Barbuda Meteorological Service to be used as guidance in the preparation of its public advisories. The results were considered useful in determining the areas most susceptible to flooding as a result of the storm surge and to estimate the possible heights of the waves expected to accompany the passage of the hurricane.

Date that model application was completed: September 1995

Case study geographical location: Antigua and Barbuda, West Indies

Vulnerability assessment indicators: Storm surge and wave heights

Methodology data requirements: Present and predicted characteristics of the hurricane

Direct participants in the application of the model of the vulnerability assessment:
National Government

Methodology objective: Compute storm surge and wave heights for Hurricane Luis

Methodology output: Storm surge and wave heights

Results of methodology application at case study site: To assist with public advisories for the hurricane and the determination of possible vulnerable sites.

Lessons learned: Real time prediction of storm surge and wave heights are useful in the preparation of public advisories issued during the occurrence of tropical storm or hurricane

Case study title:	**Seismic Vulnerability Assesment for the Public Schools in Bogotá, Colombia**

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Case study emphasis: Risk identification, evaluation and management. Disaster preparedness.

Summary: Offers a methodology for the vulnerability identification, evaluation and assessment of the school buildings in case of a seismic event, based upon the conditions of the school structures, including nonstructural elements, geographical location (amongst the microzonation soil map of Bogotá), usage and occupancy. Intended to provide the local administration with the necessary information to plan and stimulate efforts to reduce risk from a seismic event, as well as disaster preparedness and determination of the degree of destruction and corresponding economic impacts. The methodology leads to a management tool to define priorities and sequence of rehabilitation, when needed. In total more than one million square meters of building area were evaluated, including a total of 2555 buildings belonging to 645 public schools.

Date that model application was completed: April, 2000.

Case study geographical location: The procedure was applied to all school buildings belonging to the City of Bogota. Approximately one million square meters (10,000,000 ft2).

Vulnerability assessment indicators: Vulnerability Indices for over strength and flexibility. Hassan-Sozen Vulnerability Index.

Methodology data requirements: Detailed data collection for all buildings were implemented. This data was summarized in four types of questionnaires (physical, structural, non-structural, geotechnical). Where drawings existed they were used. Lack of information was supplemented by a more detailed data collection, including building inventory; microzonation soil map; usage and occupancy data. The information collected was complete enough to permit a structural seismic vulnerability evaluation of every school building.

Direct participants in the application of the model of the vulnerability assessment:

Economic and social sector participants directly involved: District Education Secretary

Methodology objective:
The objective was to develop and implement a methodology for evaluating seismic vulnerability of all school buildings belonging to the Secretary of Education of the City of Bogotá. This methodology leads to a management tool to define priorities and sequence of rehabilitation, when needed. In total more than one million square meters of building area were evaluated, including a total of 2555 buildings belonging to 645 schools.

Methodology output:
For each building vulnerability assessment was reported through three independent indices. Formal detailed vulnerability assessment and rehabilitation detailed design was performed to several schools in order to confirm the goodness of the methodology. Final result was a managing tool that permits assignment of priorities for deciding the order of rehabilitation and how to use limited economic resources in the best manner.

Results of methodology application at case study site:
From the methodology a policy for assignation of priorities depending on vulnerability level, number of exposed students, and available economic resources, was established for the city.

Lessons learned:
1) Valuable experiences were obtained in data acquisition, approximate vulnerability assessment, and formal assessment and rehabilitation design.
2) The study provided enough information to perform additional calibration and improvements to the methodology.
3) Active participation of the whole community is essential for the success of the study.

Case study title: **Sustainable Communities: Understanding Regional Hazards**

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Case study emphasis: The case study examines the economic consequences of flooding in urban and rural communities including Mandeville, LA and Franklin, LA.

Summary: The Federal Emergency Management Agency (FEMA) is releasing two natural hazard models as part of their Hazards United States (HAZUS). Two communities were identified as pilot sites to assess the application of the HAZUS riverine flood model. The two communities reflect an urban setting on Lake Ponchatrain and a rural agricultural community in Southwest coastal Louisiana. HAZUS allows the user to determine the area impacted by inland flooding and coastal hazards. In addition, HAZUS provides a utility to calculate the economic impact of a hazard on the built environment including damage to bridges, residences, business enterprises, manufacturing, and agriculture. HAZUS thus provides a means of calculating the consequences of natural hazards on a local or regional level. This approach differs from other hazard assessment methodologies that are limited to determining the area of a hazard event and showing the potential impact of the event. Vulnerability assessment approaches examine what could happen in a specific hazard event rather than the more complex "deterministic" approaches that explain the consequences of the hazard. Deterministic modeling requires far more local data such as first floor elevations that then can be compared to the depth of the water. The HAZUS application provides two tools that assist the user in creating local data sets that allow for the more complex hazard assessment. The presentation will outline the scope and purpose of the HAZUS multi-hazard application and explain what local data may be included for determining the impact of a hazard event on a local community or region.

Date that model application was completed: November 27, 2002

Case study geographical location: City and Parish / County

Vulnerability assessment indicators: Economic, social and environmental indicators

Methodology data requirements: The HAZUS application requires coastal and riverine flooding data (USGS DEM, survey cross sections or base elevation measurements from FEMA Flood Insurance Rate Maps, and previous flood boundaries such as FEMA Q3 maps) and local building inventories (points, parcels, blocks, block group or tract areas).

Direct participants in the application of the model of the vulnerability assessment:

Local, County, and State/Provincial Governments

Multilateral Development Agency	Mutlilateral Finance Agency
Bilateral Development Agency	Non Governmental Organization
Private Volunteer Organization	Research/Training Institute
Civic Association	Private Consulting Firm

Economic and social sector participants directly involved: The HAZUS application allows the user to determine the economic consequences of a specific riverine or coastal hazard event including the damage to public and private buildings (residential, commercial, manufacturing, education, government, and agriculture). The utility is linked to US Census 2000 SF3 data for detailed assessment of the impact of a hazard event.

Methodology objective: (1) To determine the nature and extent of the geographic area impacted by a riverine and coastal hazard event.; (2) To describe the economic impact of a riverine or coastal hazard event; (3) to clarify the social and environmental impact of coastal hazard events.

Methodology output: (1) GIS based areas impacted by hazard events; (2) GIS based economic, social and environmental outcomes of hazard events.

Results of methodology application at case study site: The results of the case study applications have been used to illustrate the multi-hazard risk assessment methodology for large urban areas, and coastal communities in urban and rural settings. Local user groups have been established in collaboration with the state emergency management association, state flood plane management association, state non-profit organizations, regional local government emergency management organizations, and private business groups. The case studies form the basis for explaining the purpose and limitations of the risk assessment methodology and the types of data needs for both modeling and damage assessment.

Lessons learned:

1. Local, regional, and national government agencies continue to be interested in new approaches and technologies for understanding the nature and impact of hazards.
2. Users of the hazard technologies stress the need to methodology documentation, open non-copyrighted utilities and models, suggestions and assistance in data acquiring, and technical support.
3. Case studies and illustrations of the methodology are critical in successful implementation of innovations to hazard modeling and analysis.
4. National initiatives demonstrate the value of consistent approaches to understanding hazards and their impact. The data structure provided in HAZUS allows users at many levels of government a common approach to describing hazards and their impacts.

Case study title:	**Development of new mathematical models for assessment of damages in vulnerable communities affected for the action of natural hazards.**	
Contact(s):	Name:	Oscar Mauricio Barajas Pinzón, Independent advisor in management of natural disasters and hazards.
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Case study emphasis:	Assessment of damages for the action of natural hazards in vulnerable communities – Mitigation and disaster response.	
Summary:	Development of new mathematical models for assessment of damages in vulnerable communities affected for the action of natural hazards. With this study, we developed a Software in Visual C++ called "EDES 4.0" to help us to make the assessments. This project was developed with the advising of the Colombian National University and the Colombian Red Cross.	

Date that model application was completed: 2001 - 2002.

Case study geographical location: Colombia in the most vulnerable communities in the north and in the south region of the country.

Vulnerability assessment indicators:
Damages in buildings, health centers, educational centers, recreational points, aqueduct, electrical and telephone lines based in historical damages in the past and the capability of prevention, reduction, response and recuperation of the vulnerable community affected in disasters for natural hazards.

Methodology data requirements:
- Economic capability.
- Population and density.
- Educational level.
- Quality in buildings.
- Some additional information like maps, historical damages in the past, actual local development programs in the region.

Direct participants in the application of the model of the vulnerability assessment:

Local and Subnational (regional) Governments
Multilateral Development Agency
Non Governmental Organization
Research/Training Institute

Economic and Social Sector participants directly involved:

National Government.
Regional and local Government.
NGO´s.
Academical sactor and Universities.
Advisros firms in management in natural disasters and hazards.

Methodology objective:

To develop a new mathematical model with the most important topics and variables of the vulnerable communities affected with natural hazards based in historical damages in the past and the use of new assessment techniques like neural networks, statistical analysis and the use of computers.

Methodology output:

With the use of this methodology and the new mathematical models, the output is a set of probable quantities in damages in buildings, health centers, educational centers, recreational points, aqueducts, electrical and telephones lines. And an assessment of the internal product of this country after the disaster for a natural hazard.

Results of methodology application at case study site:

- A software for assessment of damages in vulnerable communities affected for natural hazards.
- A system to assessment that consider the most important variables of vulnerability in communities affected for natural hazards.

Lessons Learned:

- Better use of statistical information of damages produced for the action of natural hazards over vulnerable communities.
- A good interaction between the vulnerable communities, the NGO´s like Colombian Red Cross, the government, the Response and Prevention National System and the academical sector like Colombian National University.

Case study title:	**A Portfolio Approach to Natural Hazard Mitigation Policy: Santa Cruz, CA**

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Case study emphasis: Risk communication with maps using an expected value/variance decision criterion for hazards mitigation. Enable the evaluation of loss-reduction policies and strategies to assist in building sustainable communities.

Summary: In the past, efforts to prevent catastrophic losses from natural hazards have largely been undertaken by individual property owners based on site-specific evaluations of risks to particular buildings. Public efforts to assess community vulnerability and encourage self-protection have focused on either aggregating site-specific estimates or adopting standards based upon broad assumptions about regional risks. This case study contains an alternative, intermediate scale approach to regional risk assessment and the evaluation of community mitigation policies. Properties or parcels are grouped into types with similar land uses and levels of hazard and hypothetical community mitigation strategies for protecting these properties are modeled like investment portfolios. The portfolios consist of investments in mitigation against the risk to a community posed by a specific natural hazard, and are defined by a community's mitigation budget and the proportion of the budget invested in locations of each type.

The usefulness of this approach is demonstrated through an integrated assessment of earthquake-induced lateral-spread ground failure risk in the Watsonville, California area. Data from the magnitude 6.9 Loma Prieta earthquake of 1989 are used to model lateral-spread ground failure susceptibility. Earth science and economic data are combined and analyzed in a geographic information system (GIS). The portfolio model is then used to evaluate the benefits of mitigating the risk in different locations. Different mitigation policies, one that prioritizes mitigation by land use type, another by hazard zone, and two others by different hazard identification estimation techniques are compared with the status quo policy of doing no further mitigation beyond that which already exists. For example, the portfolio representing a hazard

zone rule yields a higher expected return than the land-use rule portfolio does; however, the hazard zone portfolio experiences a higher standard deviation. Therefore, neither portfolio is clearly preferred. The two mitigation policies both reduce expected losses and increase overall expected community wealth compared with the status quo policy. Because these portfolios have been created in a GIS, other non-quantifiable information can be overlaid on the risk map to incorporate additional factors as input to the decision simulation.

Date that model application was completed: 2002

Case study geographical location: Santa Cruz County, CA

Vulnerability assessment indicators: Spatial probability of earthquake-triggered hazards, expected loss from a collateral earthquake hazard and hazard uncertainty, expected return on investment and uncertainty in mitigation, expected community wealth and uncertainty

Methodology data requirements: Earth science, economics, land use data, and regulatory standards or guidelines where applicable.

Direct participants in the application of the model of the vulnerability assessment:

Local, County, State/Provincial, Subnational (regional), and National Governments
Multilateral Development Agency
Private Consulting Firm
Multilateral Finance Agency
Bilateral Development Agency
Non Governmental Organization
Private Volunteer Organization
Research/Training Institute

Economic and social sector participants directly involved: --

Methodology objective: Risk communication using an expected value/variance decision criterion for hazards mitigation instead of an expected value alone as a decision making tool. Construct Decision Support System that provides rapid answers and is inexpensive to use in a geographic information system to assess community hazard vulnerability and risk at a spatial resolution that is appropriate for public decision-making. Evaluate alternative mitigation policies in the DSS that enables consensus building and cooperative decision-making in choosing an earthquake mitigation strategy.

Methodology output: User defined applications of mitigation strategies that provides hazard and risk maps, expected return on investment maps, expected wealth maps, GIS, statistical results of model runs.

Results of methodology application at case study site: Maps of earthquake-triggered liquefaction hazards and uncertainty and mitigation priorities at a community scale. Economic payoffs from alternative mitigation policies varied over an order of magnitude less than the economic investment in structural mitigation for the earthquake scenario. Decision support system was used to assess three alternative mitigation policies. DSS can be used to customize decision makers' preferences. Model is expandable to multiple hazards and can be applied in different regions.

Lessons learned: A community-scale decision support system can be cheap to use, and can retain reasonable geographic discrimination to test alternative mitigation policies. Mitigation strategies can be designed differentially to suit the particular social organization of a community, i.e., a strategy can vary across a city.

Case study title: **Use of CDCM-TAOS in the Vulnerability Assessment of Sea Defenses**

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Case study emphasis: Review Procedures for Assessing Vulnerability of Sea Defenses

Summary:

The Arbiter Of Storms (TAOS) is a system based on over 100 years of storm data, which can be used for the reliable estimation of wind, wave and surge conditions and values under the event of a tropical storm or hurricane, and was developed under the USAID-OAS-UWI Coastal Design Construction and Maintenance (CDCM) initiative in the Caribbean in 2001. This paper presents a case study of the CDCM-TAOS system utility in assessing the vulnerability and suitability of a rubble mound sea defense system on the gulf coast of Trinidad.

The system, along with other design utilities developed under CDCM, was employed to assess the site functionality and wave climate, armor layer stability and damage, and wave run-up, as inputs for a suitable cross-section design. Essential relationships between storm duration, stone weight and damage were then developed to express and ascertain the level of exposure and resulting damage the defense system would experience under the event of a 1 in 50-year Maximum Likely Event storm. The level of risk reduction desired was then defined and a suitable defense system selected for construction.

Date that model application was completed: August 2002

Case study geographical location: Point Fortin, Trinidad and Tobago, West Indies

Vulnerability assessment indicators: Wave Height, Storm Surge, Storm Duration, Sea Defense Damage

Methodology data requirements: Coordinate site location, storm return period, reliability level for event occurrence, the TAOS – CDCM system, construction materials' properties, cross section of sea defense.

Direct participants in the application of the model of the vulnerability assessment: Governmental Research/Training Institute

Methodology objective: To assess the overall resistance of sea defenses to storm/hurricane attack.

Methodology output: Relationship between storm duration and sea defense damage.

Results of methodology application at case study site: Sea Defense design was revised to account for expected levels of Damage.

Lessons learned: The CDCM-TAOS system provides reliable base of information for the design review of sea defenses.

Case study title:	**Historic Assessment of the Socio-economic Vulnerability of United States Coastal Counties**

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Case study emphasis: Socio-economic vulnerability

Summary:

Throughout the last several decades, coastal populations of the United States have steadily increased. As coastal populations rise so to do the risks of loss due to natural hazards. Until recently most research on coastal vulnerability has focused on the physical aspects of vulnerability (i.e., hurricane landfall probabilities, beach erosion, and sea-level rise). This paper however, focuses on the social and economic vulnerability of coastal counties in the United States.

Using county level United States Census data this paper models coastal vulnerability (CoVI) of United Sates coastal counties over a four decade period. CoVI spatially and temporally tracks how coastal vulnerability has changed between the years of 1960, 1970, 1980, and 1990. Additionally, this study looks at the relationship between CoVI and biophysically based coastal vulnerability indices to draw correlations between the two.

Our analysis began with over 200 socio-economic variables from the United States census on the county level for 1960, 1970, 1980, and 1990. These variables were reduced to 42, which were used in a principle component analysis to reduce the data further resulting in 9 to 11 factors. These factors were then combined in an additive model to produce a metric for each county, which denotes its relative vulnerability. Preliminary results of our analysis indicate that we can explain between 76 and 81 percent of the variance in our model as well as describe how socio-economic vulnerability has changed over time along the coastlines of the United States.

Additionally, we have statistically correlated the results of CoVI with several other coastal vulnerability indices in order to examine

the relationship between socio-economic and biophysical vulnerability. Our results suggest a relationship between those areas that indicate a high level of socio-economic and biophysical vulnerability. This analysis indicates that it is important to include both biophysical and socio-economic vulnerability in order to examine a regions overall vulnerability.

Date that model application was completed: November 20, 2002

Case study geographical location: Coastal counties of the United States

Vulnerability assessment indicators:
age, income, healthcare facilities, education, ethnicity, occupation, gender, urban/rural, housing, commerce, development

Methodology data requirements:

1. United States census data for 1960, 1970, 1980, and 1990 on the county level.
2. United States Geological Survey's (USGS) coastal vulnerability index (CVI).
3. GAP analysis and state Heritage Program Rankings.
4. Maximum wind exceedence probabilities for a category 1 hurricane (Jagger, et al., 2001).
5. Coastal Vulnerability Index (CVI) (Gornitz, et al. 1991).

Direct participants in the application of the model of the vulnerability:
Non Governmental Organization
Research/Training Institute

Economic and social sector participants directly involved: --

Methodology objective:
Examine historical change in the socio-economic vulnerability of United States coastal counties and compare the results to current biophysical vulnerability indices at the same scale.

Methodology output:

1. Socio-economic Vulnerability Index (CoVI) for United States Coastal counties for the years 1960, 1970, 1980 and 1990.
2. Correlation between CoVI and other biophysically based coastal vulnerability indices.

Results of methodology application at case study site:

1. Between 76 and 81% of our model variance was explained for each study period.
2. Increased understanding of historic shifts in socio-economic vulnerability in the United States
3. Increased understanding of the correlation between CoVI and other coastal vulnerability indices.

Lessons learned:

1. Those factors that have contributed to socio-economic vulnerability in the United States have changed over the time period of our study.

2. While spatial shifts in socio-economic vulnerability have been to the Southeast from 1960-1980, recent analysis indicates a homogenization of coastal populations.
3. A correlation exists between the socio-economic and biophysical vulnerability of United States coastal counties.

Other Case Studies

Case study title: **Fright, Suffering and Development Planning**

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Case study emphasis: Understanding the peoples' perspective and interpretation of a flood disaster

Summary: The Social Assessment methodology employed, combined a survey of areas affected by Hurricane Michele and consequent floods in 2001 in Jamaica, with in-depth Participatory Learning and Action techniques in an effort to appreciate the severity of suffering experienced. Construction of a Severity of Suffering index comprised extent of socio-emotional damage suffered, dollar severity of damage to housing, effect on household cohesion and number of household items damaged in flood. Having experienced a mean dollar loss to crops and livestock, for those least destroyed, a mean of USD 2,300 to those with houses completely damaged of mean USD 1,700, it was not surprising that 77 percent of those who experienced complete damage to their houses wished to relocate. For farmers, this decision was critical and reflected a realistic appraisal of their life chances in light of poor access to shelter assistance, agricultural financing, employment, schooling, small business financing and little national sharing of technologies and equipment. The methodology was particularly effective in being able to identify post-disaster feelings of fear, malaise, embarrassment, stress, tiredness and nervousness in addition to the generalised socio-emotional indicators. It also showed that these feelings persisted long after the waters had receded, severely affecting decision-making and attempts at a return to normalcy. These rural residents expressed the need for assistance with identification of 'hazard-free' land for farming as they were able to predict future similar disasters which they felt were imminent due to climatic changes and poor/non-existent national mitigation/reconstruction practices. The case study speaks clearly to the psycho-social implications of the experience and highlights the need to listen to established rural resident's traditional wisdom.

Date that model application was completed: April 2002

Case study geographical location: The parishes of Portland and St. Mary, Jamaica